QK1
.A427
v.41
1907

THE

AMERICAN NATURALIST

AN ILLUSTRATED MAGAZINE

OF

NATURAL HISTORY

VOLUME XLI

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
The Athenæum Press
1907

Mo. Bot. Garden
1908

INDEX

PAGE

AGASSIZ Centennial . . . 413, 461
Age, The problem of 332
Allen, G. M. Schwarz's Long-leaf Pine 539
Allen, J. A. Mutations and the geographic distribution of nearly related species . . . 653
—— Miller's Families and Genera of Bats 671
—— Ridgway's Birds of North and Middle America . . . 672
Amblystoma punctatum, Breeding habits of 381
Andrews, E. A. The attached young of the crayfish *Cambarus clarkii* and *C. diogenes* . 253
—— Earthworms as planters of trees 711
Apanteles glomeratus, Silk glands of 567
Aquaria, Aerating device for . 61
Aramides north of Panama . . 177

BANGS, O. On the wood rails, genus Aramides, occurring north of Panama 177
Beer, W. Botanical notes . . 474
Behavior of Gonionemus . . . 683
Berry, E. W. Pleistocene plants from Alabama 689
Blarina brevicauda, Habits of 495
Book reviews:
Baldwin's Mental Development 719
Barker's Anatomical Terminology 397
Beebe's Log of the Sun . . 275
Beebe's The Bird 282

PAGE

Bergen and Davis's Principles of Botany 52
Berger's Sukkulente Euphorbien 286
Bigelow's Spirit of Nature Study 395
Burkett and Poe's Cotton . . 405
Cash and Hopkinson's British Rhizopoda 800
Constantin's Transformisme . 125
Culin's Games of North American Indians 530
Dean's Chimaeroid Fishes . 132
Drew's Laboratory Manual . 592
Folsom's Entomology . . . 48
Fowler's Heterognathous Fishes 767
Guenther's Darwinism . . 44
Guyer's Animal Micrology . 196
Herrick's General Zoology . . 592
Hodge, *ed.* Handbook of American Indians 529
Hough and Sedgwick's Physiology 194, 721
Jenning's Behavior of Lower Organisms 42
Johnston's Nervous System of Vertebrates 722
Jones' Malaria 785
Kidd's Sense of Touch . . . 723
Kollmann's Altas of Human Embryology 280
Laloy's Parasitism and Mutualism 275
Lock's Progress in the Study of Variation 603
Matthew's Continents in Tertiary Times 191

PAGE

Miller's Families and Genera of Bats 671
Millikan and Gale's Physics . 41
Molisch's Purpurbakterien . 541
Montgomery's Racial Descent 719
Norton's Elements of Geology 409
Punnett's Mendelism . . . 329
Rich's Feathered Game . . 726
Ridgway's Birds of North and Middle America 672
Scharff's European Animals
Schwarz's Longleaf Pine . . 539
Skeat and Blagden's Pagan Races of the Malay Peninsula 129
de Vries' Arten und Varietäten 189
Yerkes' Dancing Mouse . . 786
Breeding habits of *Amblystoma punctatum* 381
—— of Salamandra 467
Brown-tail moth, Nettling hairs of 342

Cambarus, Attached young of . 253
Campbell, D. W. Studies on the Ophioglossaceae 139
—— Recent studies on gymnosperms 801
Capitalization of specific names 525
Cataloguing museum specimens 77
Celastrus scandens as a food supply 391
Chaetognatha, Distribution of . 241
Chalicotheres 733
Chrysler, M. A. See Jeffrey, E. C. and — 355
Chubs' nests 323, 468
Cilia, Structure of 545
Color vision, The problem of . 365
Courtis, S. A. Response of toads to sound 677
Crayfish, Attached young of . 253
Cushman, J. A. Ostracoda from southeastern Massachusetts . 35

Dane, J. M. The problem of color vision 365
Davenport, C. B. Modernized Darwinism 44

PAGE

—— Xenia in wheat 47
Davis, W. T. *Hyla andersonii* and *Rana virgatipes* in New Jersey 49
Dearborn, G. V. N. Hough and Sedgwick's Physiology . . . 194
Dillingham, F. T. The staff-tree, *Celastrus scandens*, as a former food supply of starving Indians 391
Distribution of related species 207, 241, 653
Diving beetles 477
Durnford, C. D. The flying-fish problem 65

Earthworms as planters of trees 711
Eigenmann, C. H. Fowler's "Heterognathous Fishes" with a note on the Stethaprioninae . 767
Eliot, C. W. Agassiz Centennial 413
Embryos, Specific characters in . 589
Entomology, Notes on 532, 597, 727, 798
Ernst, H. C. Molisch's Purpurbakteria 541
Exhibits at the 7th Int. Zool. Congress 657

Fierasfer affinis, Habits of . . 1
Flying-fish problem . . . 65, 347
Fowler, H. W. Records of Pennsylvania fishes . . . 5

Gastropoda, Orthogenetic variation in 607
—— Structure of cilia in . . 545
Geographic distribution of closely related species 207, 241, 653
Gill, T. Stone-gathering fishes 468
Gonionemus, Behavior of . . 683
Goodale, G. L. Burkett and Poe's Cotton 405
Grabau, A. W. Orthogenetic variation in Gastropoda . . 607
Graphic method of correlating fish environment and distribution 351

PAGE

Guyer, M. F. Method for removing gelatinous coats of eggs 400
Gymnosperms, Recent studies on 801
——, Xerophily of 813
Gynandromorphism in insects . 715

Harris, J. A. Constantin's Transformisme 125
—— de Vries' Arten und Varietäten 189
—— Cytology and mutation . 403
—— Search for mutations . . 470
—— Fungi of termite nests . . 536
—— Plant geography 601
—— Lock's Study of Variation . 603
—— Floral ecology 673
—— Xerophily in gymnosperms 813
Heterogenesis 396
Hoffmann, R. Beebe's The Bird 282
Holder, C. F. Nest of the kelp fish 587
Hrdlička, A. Quaternary remains of man in central Europe, and other notes . . . 127
—— Hodge's Handbook of American Indians 529
Hus, H. Winter rest 344
Hyla andersonii 49

Ichthyology, Literature of 335, 788
Inheritance of disease . . . 784
Insects, Notes on the structure of 532, 597, 727, 798
—— Gynandromorphism in . . 715
Instincts in birds 398

Jeffrey, E. C., and Chrysler, M. A. The microgametophyte of the Podocarpineae . . . 355
Johnson, D. W. River terraces in Vt. 126
—— Geological notes . . 192, 277
—— Norton's Elements of Geology 409
—— Recession of Niagara Falls 541
Jordan, D. S. Ichthyological notes 335, 788

PAGE

—— Flying-fish problem . . 347

Kangaroo, The young of the . 724
Kingsley, J. S. Meristic homologies in vertebrates 103
—— Zoological notes 132, 197, 401
—— Guyer's Animal Micrology 196
Kofoid, C. A. The coincident distribution of related species of pelagic organisms as illustrated by the Chaetognatha . 241
—— Jenning's Lower Organisms 42
—— Cash and Hopkinson's British Rhizopoda 800

Leaves, Development of 431, 701, 817
Leavitt, R. G. The geographic distribution of closely related species 207
Lewis, F. T. Studies of leaf development . . 431, 701, 817
—— Mendelism 329
—— Problem of Age 332
—— Mimicry 333, 781
—— Palms and soles . . 334, 723
—— Nettling hairs of the brown-tail moth 342
—— Nature study . . . 395, 595
—— Heterogenesis 396
—— Barker's Anatomical Terminology 397
—— Instincts in birds 398
—— Agassiz Centennial . . . 461
—— Preservation of native animals and plants 462
—— Problem of life 523
—— Capitalization of specific names 525
—— Specific characters in embryos 589
—— Exhibits at the 7th Int. Zool. Congress 657
—— Rich's Feathered Game . 726
—— Inheritance of disease . . 784
—— Scharff's European Animals 785
—— Yerkes' The Dancing Mouse 786

PAGE

Linton, E. Habits of *Fierasfer affinis* 1
Loomis, F. B. A note of the prairie-dog owl resembling the rattlesnake's rattle 725
Lucas, F. A. Momentum in variation 46

Matheson, R., and Ruggles, A. G. The silk glands of *Apanteles glomeratus* 567
Mating habit of *Rivellia boscii* . 465
Mendelism 329
Meristic homologies in vertebrates 103
Microgametophyte of the Podocarpineae 355
Mimicry 333, 781
Morgan, T. H. The cause of gynandromorphism in insects 715
Morrill, A. W. Description of a new species of Telenomus with observations on its habits and life history 417
Morse, M. Notes on the behavior of Gonionemus . . . 683
Murbach, L. An automatic aerating device for aquaria . 61
Murray, J. Some South American Rotifers 97
Mutants, Pink insect 773
Mutation 403, 470, 653

Necturus maculosus, Specific name of 23
Needham, J. G. Entomological notes 534
—— and Williamson, H. V. Observations on the natural history of diving beetles . . . 477
Nest of the kelp fish 587
—— of the chub . . . 323, 468
Nichols, J. F. Star nosed mole on Long Island 401
Noturus, Poison glands of . . 553

Ophioglossaceae, Studies on . 139

PAGE

Orthogenetic variation in Gastropoda 607
Ortmann, A. E. Matthew's Continents in Tertiary Times . . 191
Osteology of the Tubinares 109, 281
Ostracoda from southeastern Massachusetts 35

Palms and soles 334, 723
Parker, G. H. Zoological notes 51
—— Montgomery's Racial Descent 719
—— Johnston's Nervous System 722
Penhallow, D. P. Contributions to the Pleistocene flora of Canada 443
Pennsylvania fishes 5
Peterson, O. A. Notes on some American Chalicotheres . . 733
Piersol, W. H. Mating habit of the fly *Rivellia boscii* . . . 465
Pike, F. H. A critical and statistical study of the determination of sex, particularly in human offspring 303
Pink insect mutants . . . .
Pleistocene flora, of Alabama . 689
—— of Canada 443
Podocarpineae, Microgametophyte of 355
Poison glands of Noturus and Schilbeodes 553
Polygamy and other modes of mating among birds . . . 161
Polyodon spathula, The natural history of 753
Prairie-dog owl, A note of . . 725

Rails (Aramides) north of Panama 177
Rana virgatipes 49
Rand, H. W. The functions of the spiracle of the skate . . 287
Reed, H. D. The poison glands of Noturus and Schilbeodes . 553
Riley, W. A. Folsom's entomology 48
—— Notes on structural entomology . . . 532, 597, 727, 798

PAGE

Ritter, W. E. The significant results of a decade's study of the Tunicata 453
Rivellia boscii, Mating habit of . 465
Rotifers, South American . . 97
Ruggles, A. G. See Matheson, R. and —— 567
Ruthven, A. G. Note on the variation of scutellation in garter snakes 400
—— Large frogs from west Africa 730

Schilbeodes, Poison glands of . 553
Scutellation in garter snakes . . 400
Sex determination . . . 303, 597
Sheak, W. H. Observations on the young of the red kangaroo 724
Shrew, Habits of the Short-tailed 495
Shufeldt, R. W. Osteology of the Tubinares 109
—— Polygamy and other modes of mating among birds . . . 161
Shull, A. F. Habits of the short-tailed shrew, *Blarina brevicauda* 495
Silk glands of *Apanteles glomeratus* 567
Skate, Functions of the spiracle of 287
Smith, B. G. Volvox for laboratory use 31
—— Breeding habits of *Amblystoma punctatum* 381
Spiracle, Functions of 287
Staff-tree as a food supply . . 391
Star-nosed mole on Long Island 401
Stejneger, L. Systematic position of the Tubinares . . . 281
Stethaprioninae . . . . . .
Stockard, C. R. The natural history of *Polyodon spathula* . 753

PAGE

Telenomus, New species of . . 417
Termite nests, Fungi of . . . 536
Thompson, C. H. Berger's Sukkulente Euphorbien . . . 286
Toads, Response to sound . . 677
Trelease, W. Bergen and Davis's Botany 52
—— Botanical notes 53, 344, 405
Tubinares, Osteology of . . . 109
—— Systematic position of . . 281
Tunicata, Results of a decade's study of 453

Variation, Momentum in . . 46
Vertebrates, Meristic homologies in 103
Volvox for laboratory use . . 31

Waite, F. C. Specific name of *Necturus maculosus* 23
Walton, L. B. Cataloguing museum specimens 77
Wheeler, W. M. Pink insect mutants 773
Williams, L. W. The structure of cilia, especially in gastropods 545
—— Zoological text books . . 592
Williamson, H. V. See Needham, J. G. and —— . . . 477
Wilson, A. W. G. Chubs' nests 323
Wright, A. H. A graphic method of correlating fish environment and distribution . 351

Xenia in wheat 47

Yerkes, R. M. Baldwin's Mental Development . . . 719

VOL. XLI, NO. 481 JANUARY, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	Note on the Habits of Fierasfer	PROFESSOR EDWIN LINTON	1
II.	Records of Pennsylvania Fishes	HENRY W. FOWLER	5
III.	Specific Name of Necturus maculosus	PROFESSOR F. C. WAITE	23
IV.	Volvox for Laboratory use	BERTRAM G. SMITH	31
V.	Ostracoda from Southeastern Massachusetts	J. A. CUSHMAN	35
VI.	Notes and Literature: *Physics*, A First Course in Physics; *Biology*, Jennings' Behavior of the Lower Organisms, Modernized Darwinism; Momentum in Variation, Xenia in Wheat; *Zoölogy*, Folsom's Entomology, Observations on Hyla and Rana virgatipes; Zoölogical Laboratory Notes, Notes; *Botany*, Bergen and Davis's Principles of Botany, Rydberg's Flora of Colorado, Notes		41
VII.	Publications received		57

BOSTON, U. S. A.

GINN & COMPANY, PUBLISHERS

29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

D 4100

The American Naturalist

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca.*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Lake Forest University*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in Anthropology, General Biology, Zoology, Botany, Paleontology, Geology and Physical Geography, and Mineralogy and Petrography. The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; and in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, critical reviews of recent literature, and a quarterly record of gifts, appointments, retirements, and deaths.

All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to THE AMERICAN NATURALIST, Cambridge, Mass.

All business communications should be sent direct to the publishers.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *January, 1907* No. 481

NOTE ON THE HABITS OF *FIERASFER AFFINIS*

EDWIN LINTON

ON the 18th of June, 1906, at the Tortugas Laboratory of the Carnegie Institution I had the opportunity of watching an evicted Fierasfer in the act of returning to his lodging-place in a holothurian (*Stichopus mœbii*).

A record of this event, while perhaps not contributing anything new to science, will, it is hoped, be useful to teachers of zoölogy.

Perhaps as good a way as any of making this communication will be to narrate in order the series of events by which the knowledge came to the writer and at the same time to his associates in the laboratory, all of whom were interested witnesses.

The holothurian in question was found in a fish-trap and taken to the laboratory where it was placed in a large dish filled with sea water. Incidentally it may be remarked that the holothurian had been out of the water fully half an hour. It should also be stated that the holothurian was taken to the laboratory rather in response to the instinct of collecting than for the purpose of carrying on any experimental work.

The specimen was placed on my table and in the intervals of other work I placed various objects on it for the purpose of finding out whether it would get rid of them or not.

The holothurian was very contractile and varied in length from 150 millimeters, or less, up to the diameter of the dish, 300 millimeters.

It appeared to be indifferent to the presence of such objects as small glass dishes, allowing them to settle slowly into the yielding mass of its body wall. At length a finger-bowl, 115 millimeters

in diameter, was inverted over the animal, the edges resting on the dorsal side and about 30 millimeters from each end. Instead of making any effort to escape the animal retreated beneath the finger-bowl and at the expiration of 30 minutes had made no effort to escape.

At this point in the experiment, my patience proved inferior to that of the holothurian and I lifted the finger-bowl. When this was done a specimen of the interesting genus Fierasfer, which I have identified as *F. affinis*, was found. Evidently it had been driven to leave its host on account of the deficient supply of oxygen. The fish, which was nearly transparent, measured 124 millimeters in length, and was very slender, tapering almost uniformly from the head to the tip of the long and whip-like tail.

As soon as the finger-bowl was removed the fish began to swim

FIG. 1.— The figures represent the holothurian extended to the greatest length observed. All one-third natural size and diagrammatic.

a. Position of fish during its progress toward the posterior end of its host.

b. Fish at completion of movement which results in the insertion of the tail in the cloacal aperture.

actively about in the dish. It kept its nose close to the surface of the water, and at times even thrust its head above the surface in its eagerness to get oxygen.

After a few minutes it ceased to swim at the surface but appeared to be still uneasy. No test was made to prove what seemed to be indicated by its actions, *viz.*, that its sense of sight is defective. Judging from its subsequent behavior it was even then trying to find its customary quarters, but, to those of us who were watching, its movements began to be somewhat aimless.

At last, and, so far as I was able to judge, by accident, its nose came in contact with the holothurian near the anterior end. Immediately the fish appeared to become excited and began to feel its way back toward the posterior end of the holothurian. In its progress it bumped its nose rapidly against the side of the passive holothurian, and, as if following a scent, proceeded without any pause or regression toward the cloacal aperture. The instant that the nose of the fish touched the edge of the aperture, which was rather tightly closed, the slender tail was brought around with a very rapid whip-like movement, which terminated in a thrust whereby about 5 millimeters of the tip were darted into the narrow slit between the apposed lips of the cloaca. This movement was

FIG. 2.— *c*. The fish has straightened and is beginning to insinuate itself into the body of its host.

effected while the nose of the fish was still touching the cloacal region.

Up to this time the fish had exhibited more or less excitement but as soon as the tip of its tail had been inserted it straightened itself and began leisurely to insinuate its body tail first into its host. In this process the fish appeared to be making some use of the spines of the dorsal and ventral fins. The motion was a slow, gliding one and was not dependent on the relaxing of the cloacal sphincter of the holothurian.

The lips of the cloacal aperture remained closed during the ingress except so far as they were forced apart by the body of the fish.

The time occupied by the fish in entering the holothurian was not taken, but in my notes which I made immediately after my observations, I find that I estimated the time to be probably not more than half a minute.

In order to give some of the workers in the laboratory, who had not seen all of the events described above, an opportunity to view this interesting instance of animal behavior, the experiment was repeated.

When the finger-bowl had been removed from the holothurian a second time the fish was found to be again in the water.

Then were repeated in minutest detail the actions which I have described above. The fish swam actively at the surface of the water—part of the time with its mouth above the surface. Then it began to move in a more or less aimless fashion. Finally it touched the holothurian with its nose, this time about the middle of the length. Then followed in exact order the reactions which had been observed before, *viz.*, the rapid bumping of its nose against the side of the holothurian, the undeviating progress towards the posterior end, the whip-like motion and insertion of the tail while the nose was still in contact with the margin of the cloacal aperture, the leisurely straightening of the body, and the gradual retreat into the resisting, at least not assisting, holothurian.

It should be added that the above account is made up from notes which I wrote down immediately after the observations were made. Except in one or two details they are confirmed by Dr. Ulric Dahlgren who has kindly placed his notes at my disposal.

The above account is the story of the way one Fierasfer gained entrance to its host. Whether every individual Fierasfer would behave exactly the same, under similar circumstances, perhaps does not necessarily follow.

I am indebted to Professor Cornelia M. Clapp for reference to an excellent article on the habits, anatomy, etc., of Fierasfer by Dr. Carlo Emery, (*Fauna und Flora des Golfes von Neapel*, vol. 1, 1880). Dr. Emery notes that Fierasfer enters its host tail first.

A somewhat similar habit is indicated for the common eel by what the veteran and accurate observer, Vinal N. Edwards, tells me, *viz.*, that eels go into holes tail first.

RECORDS OF PENNSYLVANIA FISHES

HENRY W. FOWLER

Two complete accounts of the fishes of Pennsylvania have appeared, one by Cope in 1881, and the other by Dr. Bean in 1892. The first of these is of a rather general nature, though based on the author's studies while collecting about the State, and the other is to a large extent little more than an elaborated compilation of the first. In view of the desideratum of definite records for the distribution of the different species in the various streams, lakes, etc., I have collected at a number of localities, and thus am able to offer nearly complete notes for some districts. This, and an examination of the fine collection of Pennsylvania fishes in the Academy of Natural Sciences of Philadelphia will complete my records. It may be understood that no species is here included unless known to me from the examination of a Pennsylvania specimen. Further exploration will undoubtedly extend the distribution of many species, besides resulting in the acquisition of some others not now known from within our limits.

The collections in the Academy embrace chiefly those made by E. D. Cope and J. H. Slack, together with others made by T. D. Keim, B. W. Griffiths, P. Lorrilliere, W. S. Sutch, S. P. G. Lindsay, D. McCadden, H. T. Wolff, Alfred Satterthwait, J. S. Witmer, W. Stone, and myself. In this connection the writer wishes to thank Mr. Wm. E. Meehan of the State Fish Commission for permission to collect fishes in Pennsylvania with nets.

Petromyzonidæ

Petromyzon marinus Linnæus. Lamprey.— Delaware River, in the Brandywine tributaries in the Delaware basin at Stock Grange, Chester Co. (W. Stone); at Holmesburg, Philadelphia Co., Cornwells, Bucks Co., Dingmans Ferry, Pike Co. (H. T. Wolff); apparently less frequent in the Delaware than formerly.

Ichthyomyzon concolor (Kirtland). Silver Lamprey.— Allegheny River at Port Allegany, McKean Co.

Lampetra wilderi Jordan and Evermann. BROOK LAMPREY. — Kiskiminitas River (E. D. Cope); Allegheny River at Port Allegany, McKean Co.; Susquehanna tributaries at Emporium, Cameron Co.

ACIPENSERIDÆ

Acipenser sturio Linnæus. STURGEON.— Delaware River at Holmesburg, Tacony, Bridesburg, and Torresdale, in Philadelphia Co., and Cornwells, Bristol, and Tullytown in Bucks Co. I have found it fairly abundant at times and seen some large examples.

POLYODONTIDÆ

Polyodon spathula (Walbaum). PADDLE FISH.— Reported as occurring occasionally in the Allegheny River below Corydon, Warren Co., which it has been known to ascend as far as Salamanca and Olean in Cattaraugus Co., N. Y.

PSALLISOSTOMATIDÆ

Psallisostomus osseus (Linnæus). GAR PIKE.— Small examples occur in the lower Delaware River as far as Morrisville, Bucks Co., and occasionally a large one is noted.

AMIIDÆ

Amia calva Linnæus. BOW FIN.— An example from Lake Erie, obtained by Dr. Watson, may have been taken within our limits.

GLOSSODONTIDÆ

Glossodon harengoides Rafinesque. MOON EYE.— Beaver River (E. D. Cope); Youghiogheny River (E. D. Cope).

CLUPEIDÆ

Pomolobus pseudoharengus (Wilson). ALEWIFE.— Delaware River at Tinicum, Delaware Co., Holmesburg, Tacony, and Torresdale, Philadelphia Co., and Cornwells, Croydon, Bristol, Tullytown, and Morrisville, Bucks Co. Abundant in the spring.

Alosa sapidissima (Wilson). SHAD.— Delaware River at Tinicum, Delaware Co., League Island, Frankford, Tacony, Holmesburg, and Torresdale, Philadelphia Co., Cornwells, Eddington, Croydon, Bristol, Tullytown, and Morrisville, Bucks Co., and Dingmans Ferry, Pike Co. (H. T. Wolff). Some seasons more abundant than others. In the Susquehanna they are taken about Peach Bottom and McCall's Ferry, Lancaster Co.

DOROSOMATIDÆ

Dorosoma cepedianum (Le Sueur). MUD SHAD.— Delaware River at Torresdale, Philadelphia Co. (Dr. H. D. Senior), and Cornwells, Bristol, and Tullytown, Bucks Co. Apparently less abundant than formerly, though even in midwinter a few have been hauled out of the mud.

ENGRAULIDIDÆ

Anchovia mitchilli (Valenciennes). ANCHOVY.— Many examples were obtained many years ago below Philadelphia, some most likely within our limits, by Dr. Colin Arrott. They occur in the lower Delaware and are more a feature of the marine fauna.

SALMONIDÆ

Salvelinus fontinalis (Mitchill). BROOK TROUT.— Brandywine tributaries in Chester Co., and those of the Schuylkill near Port Kennedy, Montgomery Co. (D. McCadden), all in the Delaware basin; the Susquehanna basin in the Loyalsock near Lopez, Sullivan Co., and near Galeton, Potter Co.; the Allegheny basin above Port Allegheny in McKean Co., and Seven Bridges in Potter Co.; the Genesee basin about Gold in Potter Co.

ARGENTINIDÆ

Osmerus mordax (Mitchill). SMELT.— I have seen a number of examples taken from the Schuylkill and Delaware near Philadelphia.

Anguillidæ

Anguilla chrisypa Rafinesque. Eel.— Delaware River at Tinicum and Darby Creek, Delaware Co., League Island, Frankford, Tacony, Holmesburg, Torresdale, with the Pennypack Creek basin at Bustleton, in Philadelphia Co., Cornwells, Croydon, Bristol, Tullytown, and Morrisville, with the Neshaminy Creek basin at Hulmeville and Newtown, Bucks Co., and Dingmans Ferry, Pike Co. (H. T. Wolff); Susquehanna basin at Galeton, Potter Co. I did not meet with eels over the Allegheny divide in Potter and McKean Counties, and the impression is prevalent that they do not occur in the upper tributaries of either the Allegheny or the Genesee.

Cyprinidæ

Campostoma anomalum (Rafinesque). Stone Roller.— Allegheny River at Port Allegany, McKean Co., in June, 1906, where I found entirely tuberculated males; Kiskiminitas River (E. D. Cope).

Chrosomus erythrogaster eos (Cope). Red-bellied Dace.— Cotypes of *C. eos* Cope examined.

Hybognathus nuchalis Agassiz. Silvery Minnow.— Kiskiminitas River (E. D. Cope).

Hybognathus nuchalis regius (Girard). Eastern Silvery Minnow.— Delaware River at Tacony, Holmesburg, and Torresdale, Philadelphia Co., and Cornwells and Bristol, also the Neshaminy Creek basin at Hulmeville and Neshaminy Falls, in Bucks Co. Many examples were examined.

Pimephales notatus (Rafinesque). Blunt-nosed Minnow.— Kiskiminitas River (E. D. Cope) and the Allegheny River at Port Allegany, McKean Co., June, 1906.

Semotilus bullaris (Rafinesque). Fall Fish.— Delaware River basin in the Brandywine Creek basin at Kennett Square, Mendenhall, Willistown Barrens, and opposite Chadds Ford, Chester Co.; Darby Creek basin, Delaware Co.; Tacony, the Pennypack Creek basin at Holmesburg and Bustleton, the Poquessing Creek basin opposite Cornwells and Torresdale, Philadelphia

Co.; the Neshaminy Creek basin at Croydon, Hulmeville, Neshaminy Falls, and Newtown, Mill Creek basin about Bristol, and Tullytown Creek basin about Tullytown, Bucks Co.; Delaware Water Gap, Monroe Co. (E. D. Cope); Dingmans Ferry, Pike Co. (H. T. Wolff). In the Susquehanna basin I have it from the Northeast Creek at Nottingham, Chester Co., and the Conestoga Creek, Lancaster Co. (E. D. Cope).

Semotilus atromaculatus (Mitchill). CHUB. — Delaware River basin in the Brandywine Creek basin at Kennett Square, Mendenhall, and opposite Chadds Ford, Chester Co.; Cobb's Creek (E. D. Cope) and Darby Creek, Delaware Co.; Tacony Creek, the Pennypack Creek at Holmesburg and Bustleton, the Poquessing Creek at Torresdale and opposite Cornwells, Philadelphia Co.; the Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff). The Susquehanna basin in the Octoraro near Nottingham, Chester Co., and Muncy, Lycoming Co. Beaver River (E. D. Cope); Warren Co. (Dr. J. H. Slack); Kiskiminitas River (E. D. Cope); the Allegheny River at Raymonds, Potter Co. I have also found it in the headwaters of the Genesee around Gold, Potter Co.

Leuciscus vandoisulus Valenciennes. ROSY DACE. — Octoraro Creek, in the Susquehanna basin, near Nottingham, Chester Co.

Leuciscus elongatus (Kirtland). RED-SIDED DACE. — Allegheny River at Port Allegany, McKean Co., in June, 1906.

Brama crysoleucas (Mitchill). ROACH. — Delaware basin in the Brandywine Creek basin at Kennett Square, Mendenhall, and opposite Chadds Ford, Chester Co.; Tinicum and Darby Creek, Delaware Co.; Tacony Creek, the Pennypack at Holmesburg, and Bustleton, and the Poquessing at Torresdale and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co.; Pennypack at Hatboro, Montgomery Co.; Daleville, Lackawanna Co.; Dingmans Ferry, Pike Co. (H. T. Wolff), and in the Susquehanna basin from the Loyalsock Creek near Lopez, Sullivan Co.

Notropis bifrenatus (Cope). BRIDLED MINNOW. — Delaware

River in the Brandywine at Chadds Ford, Delaware Co.; the Pennypack at Holmesburg and Bustleton in Philadelphia Co., and Hatboro in Montgomery Co.; the Poquessing at Cornwells, the Neshaminy at Croydon, Hulmeville, Neshaminy Falls, and Newtown, and Mill Creek at Bristol, Bucks Co. Abundant and rather local.

Notropis cayuga Meek. Cayuga Minnow.— I have already recorded the only example seen, which was taken near Port Allegany in 1904.

Notropis procne (Cope). Swallow Minnow.— Cotypes of *Hybognathus procne* Cope examined. I have examples also from the Delaware basin taken in the Schuylkill (E. D. Cope) and the Pennypack Creek near Holmesburg, Philadelphia. A small minnow was taken on one occasion, which may be this species, in the headwaters of Northeast Creek, near Nottingham, Chester Co., in the Susquehanna basin.

Notropis hudsonius amarus (Girard). Eastern Gudgeon.— Susquehanna basin at Paradise, Lancaster Co. (J. S. Witmer). Delaware basin in the Brandywine Creek at Chadds Ford, Delaware Co.; open river and Pennypack Creek at Holmesburg, and the Poquessing at Torresdale, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, and Neshaminy Falls, and Mill Creek at Bristol, Bucks Co. More abundant in the larger streams.

Notropis whipplii (Girard). Silver Fin.— Youghiogheny River (E. D. Cope) and Kiskiminitas River (E. D. Cope).

Notropis whipplii analostanus (Girard). Eastern Silver Fin. — Delaware River basin in the Brandywine Creek at Chadds Ford, and Darby Creek, Delaware Co.; Wissahickon Creek near Barren Hill, and Pennypack Creek near Hatboro, Montgomery Co.; Tacony Creek, Pennypack at Holmesburg and Bustleton, and Poquessing Creek at Torresdale and opposite Cornwells, Philadelphia Co.; the Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, Frog Hollow, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown and Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff). It is also abundant in the Susquehanna basin where I received it from Paradise, Lancaster Co. (J. S. Witmer), and the Northeast Creek at Nottingham, Chester Co.

Notropis cornutus (Mitchill). RED FIN.—Delaware River basin in the Brandywine Creek at Kennett Square, Mendenhall, and opposite Chadds Ford, Chester Co.; Darby Creek and Ridley Creek near Willistown Barrens, Delaware Co.; Wissahickon Creek near Barren Hill, and the Pennypack at Hatboro, Montgomery Co.; Tacony Creek, Pennypack at Holmesburg and Bustleton, Poquessing Creek at Torresdale and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, Newtown, Frog Hollow, and Chalfont, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville. Bucks Co. In the Susquehanna basin in Northeast Creek at Nottingham, Chester Co.; Conestoga Creek (E. D. Cope) and Paradise, Lancaster Co. (J. S. Witmer), and Meshoppen, Elk Co. (E. D. Cope). In the Allegheny from near Croydon, Warren Co., and it also occurs farther up. Kiskiminitas River (E. D. Cope).

Notropis chalybæus (Cope). IRON-COLORED MINNOW.—Neshaminy Creek near Newton, and Mill Creek, Bristol, both in the Delaware basin, Bucks Co.

Notropis atherinoides Rafinesque. EMERALD MINNOW.—Beaver River (E. D. Cope).

Notropis rubrifrons (Cope). ROSY-FACED MINNOW.—Cotypes of *Alburnus rubrifrons* Cope examined.

Notropis photogenis (Cope). WHITE-EYED MINNOW.—Cotypes of *Squalius photogenis* Cope examined.

Notropis photogenis amœnus (Abbott). ATTRACTIVE MINNOW.—Hulmeville, in the Neshaminy Creek, Bucks Co.

Ericymba buccata Cope. SILVER-MOUTHED MINNOW.—Cotypes of the species examined.

Rhinichthys cataractæ (Valenciennes). LONG-NOSED DACE.—Delaware River basin in the Brandywine tributaries near Kennett Square and Mendenhall, Chester Co. In the Susquehanna at Paradise, Lancaster Co. (J. S. Witmer). Beaver River (E. D. Cope).

Rhinichthys atronasus (Mitchill). BLACK-NOSED DACE.—Delaware River basin in the Brandywine Creek basin at Kennett Square, Mendenhall, opposite Chadds Ford, Chester Co.; Darby, Ridley, and Cobb's Creeks, Delaware Co.; Schuylkill River, Tacony Creek, Pennypack Creek at Holmesburg, and Bustleton,

and Poquessing Creek at Torresdale, and opposite Cornwells, Philadelphia Co.; Wisahickon Creek near Barren Hill and Pennypack at Hatboro, Montgomery Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, Frog Hollow, Chalfont, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff); Daleville, Lackawanna Co. In the Susquehanna basin it occurs in the Octoraro and Northeast Creeks near Nottingham, Chester Co.; Paradise in Lancaster Co. (J. S. Witmer); the Loyalsock Creek near Lopez, Sullivan Co., and Pine Creek at Galeton and above, Potter Co. In the Allegheny River it is abundant at Coudersport and Raymonds, Potter Co. Kiskiminitas River (E. D. Cope). Youghiogheny River (E. D. Cope). Genesee basin near Gold, Potter Co. Potomac drainage of Fulton Co., (W. Stone).

Hybopsis kentuckiensis (Rafinesque). Horned Chub.—Susquehanna basin in Elk Creek, Chester Co. (E. D. Cope); Conestoga Creek, Lancaster Co. (E. D. Cope). Beaver River (E. D. Cope); Youghiogheny River (E. D. Cope); Kiskiminitas River (E. D. Cope); Warren Co. (Dr. J. H. Slack); Allegheny River at Port Allegany, McKean Co.

Exoglossum maxillingua (Le Sueur). Cut-lips Minnow.— Allegheny River at Port Allegany, McKean Co.

Catostomatidæ

Carpiodes cyprinus (Le Sueur). Eastern Carp Sucker.—Conestoga Creek, in the Susquehanna basin, Lancaster Co. (E. D. Cope).

Cycleptus elongatus (Le Sueur). Black Horse.— Kiskiminitas River (E. D. Cope).

Catostomus commersonnii (Lacépède). Common Sucker.— Delaware River in the Brandywine tributaries at Kennett Square, Mendenhall and opposite Chadds Ford, Chester Co.; Tinicum, Ridley, Cobb's and Darby Creeks, Delaware Co.; Pennypack Creek at Hatboro, Montgomery Co.; Tacony Creek, Pennypack Creek at Holmesburg and Bustleton, Poquessing Creek at Torresdale and opposite Cornwells, Philadelphia Co.; Neshaminy Creek

at Croydon, Hulmeville, Chalfont, Frog Hollow, Neshaminy Falls, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co.; Delaware Water Gap, Monroe Co. (E. D. Cope); Dingmans Ferry, Pike Co. (H. T. Wolff). In the Susquehanna basin in the Northeast and Octoraro Creeks near Nottingham, Chester Co.; Conestoga Creek (E. D. Cope) and Paradise, Lancaster Co. (J. S. Witmer). In the Allegheny River it occurs at Port Allegany in McKean Co.

Catostomus nigricans Le Sueur. BLACK SUCKER.— In the Susquehanna basin in the Conestoga Creek (J. Stauffer) and at Paradise, Lancaster Co. (J. S. Witmer); Octoraro Creek near Nottingham, Chester Co. Kiskiminitas River (E. D. Cope). I have not positively identified this from the Delaware basin.

Erimyzon sucetta oblongus (Mitchill). MULLET. — Delaware River basin in the Brandywine tributaries at Kennett Square and Mendenhall, Chester Co.; Brandywine at Chadds Ford, Ridley and Darby Creeks, Delaware Co.; Tacony Creek, river and Pennypack Creek at Holmesburg and Bustleton, Poquessing Creek at Torresdale, and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co. In the Susquehanna basin from Center Co. (Dr. H. Allport). Genesee River at Gold, Potter Co.

Moxostoma anisurum (Rafinesque). WHITE-NOSED SUCKER.— Beaver River (E. D. Cope) and Youghiogheny River (E. D. Cope).

Moxostoma aureolum (Le Sueur). GOLDEN RED HORSE.— Beaver River (E. D. Cope) and Youghiogheny River (E. D. Cope).

Moxostoma macrolepidotum (Le Sueur). RED HORSE.—Conestoga Creek, Lancaster Co. (E. D. Cope).

Moxostoma breviceps (Cope). LONG-TAILED RED HORSE.— Type of *Ptychostomus breviceps* Cope examined.

Placopharynx duquesnii (Le Sueur). BIG-JAWED SUCKER.— Beaver River (E. D. Cope).

SILURIDÆ

Ictalurus punctatus (Rafinesque). BLUE CAT.— Beaver River (E. D. Cope).

Ameiurus catus (Linnæus). WHITE CAT.— Delaware River

basin in tributaries in Chester Co. (V. Bernard); Holmesburg and Torresdale, Philadelphia Co.; Bristol, Bucks Co.; Susquehanna River (E. D. Cope).

Ameiurus nebulosus (Le Sueur). YELLOW CAT.— Delaware River basin in the Brandywine tributaries at Kennett Square and Mendenhall, Chester Co.; Tinicum, Brandywine at Chadds Ford, Darby, Ridley, and Cobb's Creeks, Delaware Co.; Jenkintown, Montgomery Co. (H. Crawley); Falls of Schuylkill (Dr. Uhler), Tacony Creek, river and Pennypack at Holmesburg and Bustleton, Poquessing Creek at Torresdale, and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, Chalfont, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff); Susquehanna River (E. D. Cope); Northeast Creek near Nottingham, Chester Co.; Conestoga Creek, Lancaster Co. (E. D. Cope); Allegheny River at Coudersport and Perryville, Potter Co.

Gronias nigrilabris Cope. BLIND CAT.— Cotypes of the species examined.

Leptops olivaris (Rafinesque). MUD CAT.— Youghiogheny River (E. D. Cope).

Schilbeodes gyrinus (Mitchill). TADPOLE STONE CAT.— Delaware River at Holmesburg, Philadelphia Co.; Mill Creek at Bristol, and Tullytown, Bucks Co.; Delaware Water Gap, Monroe Co. (E. D. Cope); Dingmans Ferry, Pike Co. (H. T. Wolff). In the Susquehanna from the Loyalsock Creek near Lopez, Sullivan Co. In the Genesee below Gold, Potter Co.

Schilbeodes insignis (Richardson). MARGINED STONE CAT.— Delaware River in the Schuylkill and at Holmesburg, Philadelphia Co.; Susquehanna basin at Carlisle, Cumberland Co. (S. F. Baird); Conestoga Creek (J. Stauffer) and Paradise, Lancaster Co. (J. S. Witmer).

ESOCIDÆ

Esox americanus (Gmelin). BANDED PICKEREL.— Delaware River basin in the Brandywine tributaries at Kennett Square and Mendenhall, Chester Co.; Tinicum and Darby Creek, Delaware Co.; Tacony Creek, Pennypack Creek at Holmesburg, and Poquessing Creek at Torresdale and opposite Cornwells, Philadel-

phia Co.; Neshaminy Creek at Neshaminy Falls and Newtown, Mill Creek at Bristol, Tullytown, and Morrisville, Bucks Co. In the Octoraro Creek of the Susquehanna basin near Nottingham, Chester Co.

Esox vermiculatus Le Sueur. WESTERN PICKEREL.— Allegheny River in Potter County.

Esox reticulatus Le Sueur. CHAIN PIKE.— Rock Hill Pond and Dingmans Ferry, in the Delaware Basin, Pike Co. (H. T. Wolff).

Esox lucius Linnæus. PIKE.— Although I did not secure any examples of this species in the Allegheny River while at Port Allegany, in McKean Co., in 1904, it was reported as occurring farther down stream. One from Lake Erie may have been from within our limits (Dr. Watson).

Esox masquinongy ohiensis (Kirtland). OHIO RIVER MUSKALLUNGE.— Reported to occur in the Allegheny as far as Corydon, Warren Co., and in New York to Olean. Warren Co. (Dr. J. H. Slack).

UMBRIDÆ

Umbra limi pygmæa (De Kay). MUD MINNOW.— Delaware River at Philadelphia and Holmesburg, Philadelphia Co.; Bristol and Tullytown, Bucks Co.; Schuylkill River (Dr. Harlan).

PŒCILIIDÆ

Fundulus heteroclitus macrolepidotus (Walbaum). MUMMICHOG. — Delaware River in tide-water, at Tinicum, Delaware Co.; League Island, Tacony, Holmesburg, and Torresdale, Philadelphia Co.; Cornwells, Croydon, Bristol, Tullytown, and Morrisville, Bucks Co.

Fundulus diaphanus (Le Sueur). BARRED KILLIFISH.— Delaware River in tide-water and above, Brandywine basin in Chester Co. at Kennett Square; Brandywine at Chadds Ford, Darby and Ridley Creeks, Delaware Co.; Tacony Creek, Pennypack Creek at Holmesburg and Bustleton, Poquessing Creek at Torresdale and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, and Newtown, Mill

Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co.; Montgomery Co.; the Susquehanna basin at Paradise (J. S. Witmer) and Lancaster Co. (E. D. Cope); Warren County (Dr. J. H. Slack).

MASTACCEMBELIDÆ

Tylosurus marinus (Walbaum). GREEN GAR.— Delaware River (Dr. Uhler), at Bristol, Bucks Co.; Susquehanna River (E. D. Cope).

ATHERINIDÆ

Labidesthes sicculus (Cope). BROOK SILVERSIDE.— Youghiogheny River (E. D. Cope).

GASTEROSTERIDÆ

Eucalia inconstans (Kirtland). BROOK STICKLEBACK.— Erie, Erie Co.

Apeltes quadracus (Mitchill). FOUR-SPINED STICKLEBACK.— Delaware River, in tide-water, at Tinicum, Delaware Co.; Tacony, Holmesburg, and Torresdale, Philadelphia Co.; Cornwells, Croydon, Bristol, Tullytown, and Morrisville, Bucks Co.

APHREDODERIDÆ

Aphredoderus sayanus (Gilliams). PIRATE PERCH.— Delaware River at Tinicum, Delaware Co.; League Island, Tacony, Holmesburg, and Torresdale, Philadelphia Co.; Mill Creek and the river at Bristol, Bucks Co.

CENTRARCHIDÆ

Pomoxis annularis Rafinesque. CRAPPIE.— Kiskiminitas River (E. D. Cope). I have an example from the Delaware at Brownsville, Bucks Co. (J. G. Dillin).

Ambloplites rupestris (Rafinesque). ROCK BASS.— Beaver River (E. D. Cope), Warren Co. (Dr. J. H. Slack), and Kiskiminitas River (E. D. Cope).

Enneacanthus gloriosus (Holbrook). Blue-spotted Sunfish. — Delaware River at League Island (Professor Wm. M. Gabb), and Holmesburg, Philadelphia Co.; river and Mill Creek at Bristol, Bucks Co. In the Susquehanna from the Conestoga Creek, Lancaster Co.

Enneacanthus obesus (Girard). Sphagnum Sunfish.—Found only in the ditches of the lower part of Philadelphia along the Delaware.

Mesogonistius chætodon (Baird). Banded Sunfish.— Delaware River at Holmesburg, Philadelphia Co., and Bristol, Bucks Co.

Lepomis auritus (Linnæus). Red-breasted Sunfish.— Delaware River basin in the Brandywine tributaries (Dr. H. Allen), Londongrove (E. D. Cope); Chadds Ford on the Brandywine, Darby, Ridley, and Cobb's Creeks, Delaware Co.; Montgomery Co. (W. Cassin), and Pennypack at Hatboro; Tacony Creek, Pennypack at Holmesburg and Bustleton, Poquessing at Torresdale and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls, and Newtown, Mill Creek at Bristol, Tullytown and Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff). In the Susquehanna basin from the Octoraro Creek (E. D. Cope) and Conestoga Creek, Lancaster Co. (E. D. Cope), and Paradise, Lancaster Co. (J. S. Witmer).

Lepomis megalotis (Rafinesque). Long-eared Sunfish.— Kiskiminitas River (E. D. Cope).

Lepomis macrochirus Rafinesque. Large-finned Sunfish. — Cotypes of *Lepomotis nephelus* Cope examined.

Lepomis palladus (Mitchill). Blue-gill Sunfish.— Warren Co. (Dr. J. H. Slack); Kiskiminitas River (E. D. Cope).

Eupomotis gibbosus (Linnæus). Common Sunfish.— Delaware River basin in tributaries of Brandywine near Kennett Square, Chester Co. (E. D. Cope and H. Allen); Brandywine at Chadds Ford, Ridley, Darby, and Cobb's Creek, and Tinicum, Delaware Co.; Jenkintown and Hatboro, Montgomery Co.; Tacony Creek, Pennypack Creek at Holmesburg and Bustleton, Poquessing at Torresdale and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls,

and Newtown, Bristol, and Mill Creek, Tullytown and Tullytown Creek, and Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff). In the Susquehanna from the Conestoga Creek, Lancaster Co. (E. D. Cope); the Loyalsock near Lopez, Sullivan Co.; Octoraro Creek (E. D. Cope). Erie, Erie Co. (C. Rutter).

Micropterus dolomieu Lacépède. SMALL-MOUTHED BASS.— Youghiogheny River (E. D. Cope) and the Allegheny at Corydon, Warren Co., and met with as far as Olean, N. Y.

Micropterus salmoides (Lacépède). LARGE-MOUTHED BASS.— Warren Co.

PERCIDÆ

Stizostedion vitreum salmoneum (Rafinesque). BLUE PIKE.— Warren Co. (Dr. J. H. Slack), Beaver River (E. D. Cope), and Youghiogheny River (E. D. Cope).

Stizostedion canadense griseum (De Kay). SAUGER.— Warren Co. (Dr. J. H. Slack), Beaver River (E. D. Cope), and Youghiogheny River (E. D. Cope).

Perca flavescens (Mitchill). YELLOW PERCH.— Delaware River in Darby Creek, Delaware Co.; river and Pennypack Creek at Holmesburg, and Poquessing Creek at Torresdale, Philadelphia Co.; Neshaminy Creek at Croydon, Hulmeville, Neshaminy Falls and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown and Morrisville, Bucks Co. In the Susquehanna basin from the Conestoga Creek in Lancaster Co. (E. D. Cope).

Percina caprodes (Rafinesque). LOG PERCH.— Type of *Perca nebulosa* Haldeman examined. Youghiogheny River (E. D. Cope) and Kiskiminitas River.

Hadropterus macrocephalus (Cope). LONG-HEADED DARTER. — Cotype of *Etheostoma macrocephalum* Cope examined.

Hadropterus peltatus (Cope). SHIELDED DARTER.— Type of *Etheostoma peltatum* Stauffer, in Cope, examined.

Diplesion blennioides (Rafinesque). GREEN-SIDED DARTER.— Beaver River (E. D. Cope).

Boleosoma nigrum (Rafinesque). JOHNNY DARTER.— Cotypes of *B. olmstedi brevipinnis* Cope examined.

Boleosoma nigrum olmstedi (Storer). TESSELLATED DARTER. — Delaware River basin in the Brandywine tributaries at Kennett

Square, Mendenhall and opposite Chadds Ford, Chester Co.; Brandywine at Chadds Ford, Ridley, Darby, and Cobb's Creek, and Tinicum, Delaware Co.; Pennypack at Hatboro, and Jenkintown, Montgomery Co.; League Island, Tacony Creek, Frankford Creek, Pennypack Creek at Holmesburg and Bustleton, and Poquessing Creek at Torresdale, and opposite Cornwells, Philadelphia Co.; Neshaminy Creek at Croydon, Newportville, Hulmeville, Neshaminy Falls, Frog Hollow, and Newtown, Mill Creek at Bristol, Tullytown Creek at Tullytown, and Morrisville, Bucks Co.; Dingmans Ferry, Pike Co. (H. T. Wolff). In the Susquehanna basin I have it from the Octoraro Creek at Nottingham in Chester Co., the Loyalsock near Lopez, Sullivan Co., and the Pequea at Paradise, Lancaster Co. (J. S. Witmer), besides the type of *Percina minima* Haldeman. The accompanying figure represents a remarkable variation of fin-rays seen in an example I secured at Holmesburg, Philadelphia, September 11th, 1898. Although I have not seen the type of *Boleosoma æsopus* Cope my Loyalsock examples go far to establish it as a pure synonym of this fish.

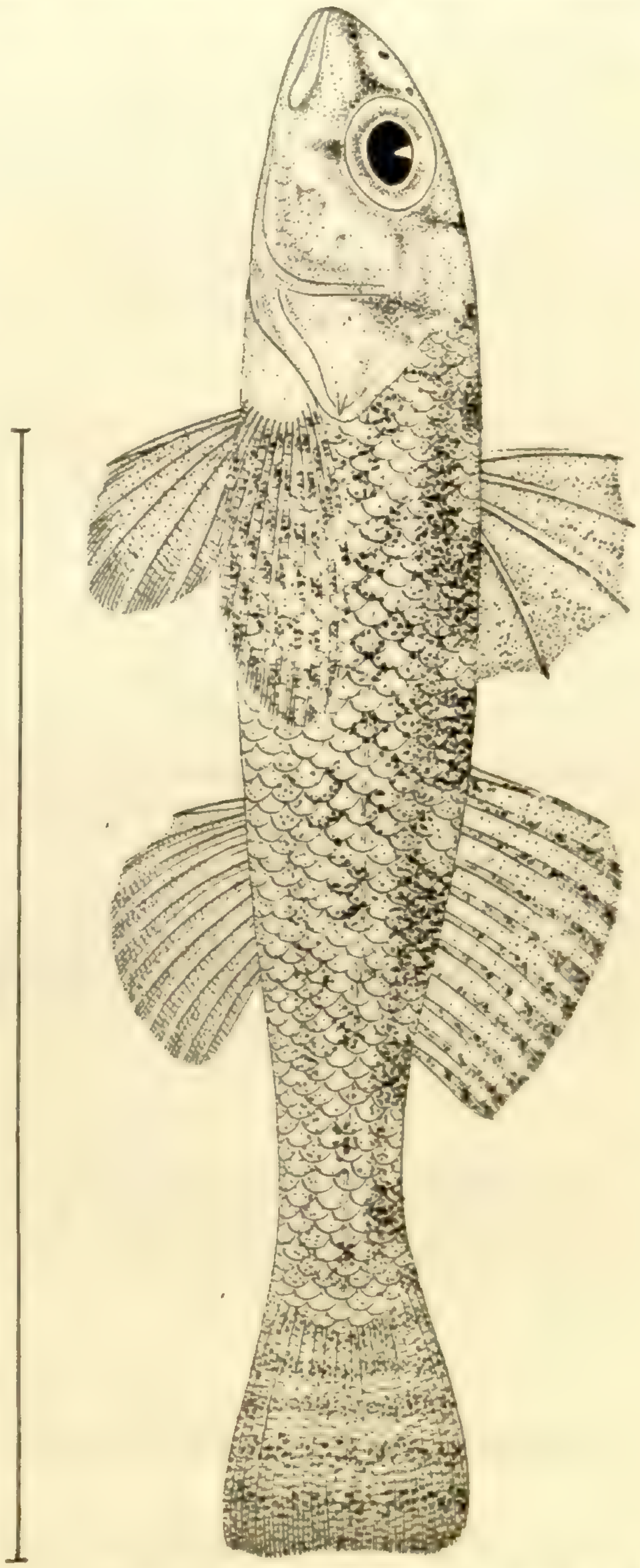


Fig. 1.— Variation of *Boleosoma nigrum olmstedi* (Storer).

Etheostoma cæruleum Storer. BLUE DARTER.— Kiskiminitas River (E. D. Cope).

Etheostoma flabellare Rafinesque. FAN-TAILED DARTER.— Kiskiminitas River (E. D. Cope); Youghiogheny River (E. D. Cope); Pittsburgh (Jacob Green); Allegheny River at Port Allegany in McKean Co. during July and August of 1904 and June of 1906, where it is abundant.

Boleichthys fusiformis erochrous (Cope). SPHAGNUM DARTER. — Delaware basin in Mill Creek near Bristol, Bucks Co.

SERRANIDÆ

Roccus lineatus (Bloch). STRIPED BASS.— Delaware River basin at Tinicum, Delaware Co.; League Island, Tacony, Holmesburg, and Torresdale, Philadelphia Co.; Cornwells, Bristol, Tullytown, and Morrisville, Bucks Co. In the Susquehanna basin I have it from the Conestoga in Lancaster Co. (E. D. Cope).

Roccus chrysops (Rafinesque). WHITE BASS.— Reported from just below the headwaters of the Genesee in Potter Co. near Gold.

Morone americana (Gmelin). WHITE PERCH.— Delaware River at League Island, Tacony, Holmesburg, and Torresdale, Philadelphia Co., Cornwells, Bristol, Croydon, Tullytown, and Morrisville, Bucks Co.

SCIÆNIDÆ

Aplodinotus grunniens Rafinesque. FRESH-WATER DRUM.— One from Lake Erie (Dr. Watson) may have been taken in our limits.

COTTIDÆ

Uranidea gracilis viscosa (Haldeman). MILLER'S THUMB.— The Delaware basin in the Brandywine tributaries near West Chester, Chester Co.; in the Schuylkill basin near Port Kennedy, Montgomery Co. (D. McCadden), and Douglassville, Berks Co. (S. N. Rhoads); in the Neshaminy basin near New Britain, Bucks Co. (Dr. C. C. Abbott). In the Susquehanna basin in Spruce Creek, Huntingdon Co. In the Genesee basin at Gold, Potter Co., also other examples from the same County (E. Harris).

Soleidæ

Achirus fasciatus Lacépède. Sole.—Schuylkill River in the Delaware basin (Dr. Harlan) and Bristol, Bucks Co. (Dr. J. De B. Abbott).

Gadidæ

Lota maculosa (Le Sueur). Ling.—Erie, Erie Co.; Susquehanna basin at Muncy, Lycoming Co. (E. D. Cope).

SPECIFIC NAME OF *NECTURUS MACULOSUS*

F. C. WAITE

In view of the fact that this animal is now extensively used in research and teaching, and since the majority of teachers and writers follow Cope ('89) and erroneously use the name *Necturus maculatus*, it seems worth while to call attention to the correct terminology.

There has been considerable confusion in the nomenclature of this form since it was first described. Minor variations have in several cases received specific names, and in the earlier literature it was frequently confused with *Cryptobranchus allegheniensis* of which it was for a time considered the larva.

The first scientific description of this animal was by Schneider in 1799 from a single specimen in the museum at Brunswick. This specimen came from Lake Champlain. Schneider did not consider it a new genus but put it under the European genus Salamandra without appending any specific name.[1]

Lacépède ('07) described a museum specimen, saying that it had never been before described, evidently not knowing of Schneider's description. He recognized that it differed from Salamandra and therefore referred it to the genus Proteus, naming it *Proteus tetradactyle* with the provision that if it were found to be a larva, it should be called *Salamandra tetradactyle*.

Barton ('07, pp. 196–7), describes "a large species of Salamandra" which he proposes to call *S. horrida*, or *maxima*, or *gigantea*. It is evident from a reading of his paper that he has confused Necturus and Cryptobranchus, and the general inaccuracy of his description makes his contribution of little value.

Rafinesque ('18, p. 40), gave a brief preliminary description of this salamander under the name *Sirena maculosa*. He, however, recognized, as the following quotation shows, that it might represent a new genus (p. 40): "In Zoology my discoveries are par-

[1] The original paper is not available. I quote from Holbrook ('42).

ticularly important consisting of about 25 new undescribed quadrupeds, 30 new birds and about 32 new reptiles" * * * * "Among so many undescribed things it must follow that several may constitute new genera. . . . I propose to select 8 N. G. and 10 N. Sp. in order to convey an idea of the whole.

(p. 41) I. N. Sp. Sirena maculosa, (A Reptile). Body olivaceous brown, covered with large unequal blackish spots * * * * "This spotted siren bears the generic name *Water Puppet* along with S. lutea and S. fusca."

A year later, after he had been able to study his collections, Rafinesque ('19) erected the new genus Necturus to include this form. I quote part of his description, (p. 418): "IIIe Classe. Reptiles * * * * 7. Necturus (Batracien) Different des genres *Salamandra*, *Triturus* (Triton, Laur.), *Larvarius* (Proteus, Aurt.), par queue comprimée 4 doigts séparés a tous les 4 pieds, branchies extérieures persistent communement jusqu' à la vieillesse. . . . Espèces: N. maculatus, N. lutescens, N. fuscus, N. marginatus, N. axolotes?, N. anguillaris, N. operculatus, etc."

A year later Rafinesque ('20) again describes this form, (p. 4): "III Class. Erpetiá — the Reptiles. . . .17. Necturus maculosus, olive brown covered with large unequal black spots. . . . My genus *Necturus* (70 N. G. An.) is distinguished from *Triturus* by having teeth, four toes to all the feet and external gills present to a late period. . . .18. Necturus luteus. . . .19. Necturus phosphoreus" * * *.

Mitchill ('21, p. 183) says in regard to this form: "From such survey as I have been capable of making I am inclined to consider him a Proteus; but of a species different to that known to European naturalists." Later, in a very extensive description with good plate, (Mitchill, '24) he describes a specimen from Lake Erie and recognizes that it differs from the genus Proteus, but is "averse to unnecessary multiplication of genera."

In 1823 Say (James, '23, vol. 1, p. 5, footnote) describes specimens from the Allegheny River, with permanent branchiæ. He says that it is caught at Pittsburg but is not so abundant as *S. alleghaniensis*. He gives the new name *Triton lateralis*.

Harlan ('24, p. 233, pl. 16), evidently unaware of the papers of Rafinesque, erected the new genus Menobranchus. "The *Am-*

phiuma, the *Siren*, the *Proteus* and the *Salamandra* will be acknowledged by all to constitute separate genera. The *lateralis* and *allegheniensis* not belonging to any of these will require appropriate generic names....As the most prominent feature distinguishing the *T. lateralis* from the *Salamandra* is its persistent branchiæ, we have preferred a name significant of this fact. Menobranchus. Generic characters. Persistent branchiæ, two rows of teeth in the upper and one row in the lower jaw; four footed, four toes to each foot, clawless." He describes two species, *M. lateralis* and *M. tetradactylus*. Since these were found to be but variations of the same species and since the term *tetradactylus* described a generic character, the first species, only, held.

Harlan erected the genus Abranchus to include the *allegheniensis*, but in a note a few months later (same journal and volume, p. 270) he changed this to Menopoma having learned that the name Abranchus was preëmpted for a genus of nudibranch molluscs.

Barnes ('26) calls it *Proteus lateralis* and says (p. 287) that "the first specific name given was by Mr. Say who called it *lateralis* in allusion to the black lateral line. The discoveries already made ....show that the character from which he derived this is variable." He dissents from Harlan and does not think that a new genus should be established. He evidently knew nothing of Rafinesque's description.

In a later note (Barnes, '27, p. 68), he says: "Dr. Mitchill has laterly called it *Proteus maculatus*, which as it is a good descriptive name....I am disposed to adopt." Mitchill had evidently gotten the *maculatus* from Rafinesque's second paper ('19) but had not seen the first ('18) or third ('20) papers.

Fitzinger ('26, p. 43) gave a new name to the genus. "Genus. Phaenerobranchus. Aus Lacépède's Proteus tetradactylus, Say's Triton lateralis, aus Nord Amerika, schuf ich die Gattung Phaenerobranchus (Menobranchus, Harlan; Necturus, Rafinesque)." Under the list of reptiles in the Zoölogical Museum at Vienna he includes (p. 66) "Phaenerobranchus cepedii (=Proteus tetradactylus, La Cepede)."

Harlan ('27) in his synopsis includes (p. 323) "*Menobranchus lateralis*" and this name was followed by many writers.

Wagler ('30, p. 210) returns to the generic name of Necturus,

and quotes as synonyms, *Proteus tetradactylus* Lacépède, *Triton lateralis* Say, and *Menobranchus lateralis* Harlan.

Tschudi ('38, p. 97) adopts *Menobranchus lateralis.*

Holbrook ('42, vol. 5) describes two species of Menobranchus: (p. 111) *M. maculatus* (Barnes) in which he makes no reference to Rafinesque, and (p. 115) *M. lateralis* (Say). He states that the two species may be only geographical varieties.

DeKay ('42, p. 87, pl. 18, fig. 45) uses *Menobranchus lateralis* and does not refer to Rafinesque.

Baird ('50), in his "Revision of the Tailed-Batrachia" gives correct references to Rafinesque's three papers and while adopting his generic name, adheres to Say's specific name (which was given five years later) giving the name of the form as *Necturus lateralis* 1823, which was the date of Say's description, although Say did not use the term Necturus.

Gray ('50) gives the reference to Rafinesque's three papers and is the first to adopt the correct name *Necturus maculosus.* However, in the second edition of this work (Boulenger, '82, p. 84) reference is made only to Rafinesque's second ('19) paper and the term *Necturus maculatus* is taken.

Dumeril and Bibron ('54, p. 183) use Harlan's term *Menobranchus lateralis.*

Finally, Cope ('89, p. 23) adopts the name *Necturus maculatus* in spite of the fact that his references to synonyms shows that he had consulted all of Rafinesque's papers.

The following are part of the Laws of priority as published in the *International Rules of Nomenclature* (:05):—

(p. 35) "Art 25. The valid name of a genus or species can be only that under which it was first designated on the condition: (*a*) That this name was published and accompanied by an indication or a definition or a description and (*b*) That the author applied the principles of binary nomenclature."

(p. 36) "Art. 28. A genus formed by the union of two or more genera or subgenera takes the oldest valid generic or subgeneric name of its components. The same rule obtains when two or more species or subspecies are united to form a single species or subspecies.

(p. 37) "Art. 32. A generic or a specific name once published

cannot be rejected even by its author because of inappropriateness."

Although Schneider gave the first description of this form he did not follow the binary system nor did he recognize it as a separate genus.

There can be no question that Rafinesque ('19) was the first to erect and name a new genus to receive this form.

The specific name *tetradactylus* given by Lacépède ('07) cannot hold because it describes a generic character ("4 doigts séparés à tous les 4 pieds") in the new genus Necturus of Rafinesque.

The description by Barton ('07), is certainly so inaccurate, including his hesitation between three specific names, that his paper can have little weight.

The first scientific description with the use of a binary nomenclature is that of Rafinesque ('18). Here the specific name is *maculosa*. According to Art. 32 of the rules on priority this term could not have been changed by Rafinesque if he had wished to do so. The term *maculatus* used in his 1819 paper is either an unintentional slip on his part or a typographical error. At any rate the use of the term *maculosus* in his '20 paper, which was published under his immediate direction with opportunity to correct proof, shows that he preferred the original adjective form *maculosus* to the participial form *maculatus*. Such is certainly the better grammatical usage.

The confusion has arisen from the fact that the first ('18) paper was printed in a rather obscure literary periodical where scientific men were unlikely to see it. Likewise the third paper ('20) was published in an obscure private publication, a serial which did not continue and so was easily lost sight of. The second paper ('19) in which the error occurred was in a prominent scientific journal and thus came to be generally known.

In the past ten years although many papers have been written on Necturus, two only have, as far as I know, used the correct nomenclature. These are Eycleshymer (:06) and Waite ('97).

I believe that it is clear from the foreoging that the correct name is *Necturus maculosus* and I hope that this may come into general use.

Western Reserve University.

LITERATURE.

'05. International Rules of Nomenclature, adopted by the International Congress of Zoölogy, Paris, 1905.

Baird, S. F.

'50. Revision of the North American Tailed-Batrachia with Descriptions of a New Genus and Species. *Journ. Acad. Nat. Sci., Philadelphia,* ser. 2, vol. I, pp. 281–294.

Barnes, D. H.

'26. An Arrangement of the Genera of the Batracian Animals with a Description of the more Remarkable Species including a monograph of the Doubtful Reptiles. *Amer. Journ. Sci. and Arts,* ser. 1, vol. 11, pp. 268-297.

Barnes, D. H.

'27. Note on the Doubtful Reptils. *Amer. Journ. Sci. and Arts,* ser. 1, vol. 13, pp. 66–70.

Barton, B. S.

'07. [Scientific Notes]. *Phila. Med. and Physical Journ.,* suppl. 2, sect. 2.

Boulenger, G. A.

'82. Catalogue of the Batrachia Gradientia, s. Caudata and Batrachia Apoda in the Collection of the British Museum. London, 1882. (Second edition of Gray, '50).

Cope, E. D.

'89. The Batrachia of North America. *Bull. 34, U. S. Nat. Mus.,* Washington.

DeKay, J. E.

'42. Zoology of New York. Part III. Reptiles and Amphibia.

Duméril, A. M. C. et Bibron, G.

'54. Erpetologié générale ou histoire naturelle complète des Reptiles. Tome 9, Paris.

Eycleshymer, A. C.

'06. The Habits of *Necturus maculosus. Amer. Nat.,* vol. 40, pp. 123–136.

Fitzinger, L. I.

'26. Neue Classification der Reptilien. Wien.

Gray, J. E.

'50. Catalogue of the Specimens of Amphibia in the Collection of the British Museum. Part II. Batrachia Gradientia etc. London.

HARLAN, R.
'24. Observations on the Genus Salamandra with the Anatomy of the *Salamandra gigantea* (Barton) or *S. allegheniensis* (Michaux) and two New Genera proposed. *Ann. Lyc. Nat. Hist.*, vol. 1, pt. 2, pp. 222–234.

HARLAN, R.
'27. Genera of North American Reptilia and a Synopsis of the Species. *Journ. Acad. Nat. Sci. Philadelphia*, vol. 5, pt. 2.

HOLBROOK, J. E.
'42. North American Herpetology. Ed. 2, 5 vols., Philadelphia.

JAMES, EDWIN, (editor).
'23. Account of an Expedition from Pittsburg to the Rocky Mountains in 1819 and 1820 under the command of Major S. H. Long. 2 vols., Philadelphia, and 3 vols., London.

LACÉPÈDE, M. DE.
'07. Sur une espèce de quadrupède ovipare non encore décrite. *Ann. Mus. Hist. Nat. Paris*, vol. 10, pp. 230–235, pl. 17.

MITCHILL, S. L.
'21. The Proteus of the North American Lakes. *Amer. Journ. Sci. and Arts*, ser. 1, vol. 4, pp. 181–183.

MITCHILL, S. L.
'24. Observations on Several Reptiles of North America which seem to belong to the family Proteus. *Amer. Journ. Sci. and Arts*, ser. 1, vol. 7, pp. 63–69, pl. 2.

RAFINESQUE, C. S.
'18. Purther Accounts of Discoveries in Natural History in the Western States. *Amer. Month. Mag. and Crit. Rev.*, vol. 4, pp. 39–42, New York, Nov. 1818.

RAFINESQUE, C. S.
'19. Prodrome de 70 nouveaux Genres d'animaux découverts dans l'interieur des Etats-Unis d'Amérique durant l'année 1818. *Journ. Physique, Chemie*, et *Hist. Nat.*, vol. 88, pp. 417–429, June 1819.

RAFINESQUE, C. S.
'20. Annals of Nature or Annual Synopsis of new Genera of Plants and Animals. First Annual Number, pp. 1–16, Transylvania University, Lexington, Ky., Mch. 1820.

SAY.
'23. Vide James, Edwin (editor).

SCHNEIDER, J. G.
1799. Historiæ Amphibiorum Naturalis et Litterariae, Jena.

TSCHUDI, J. J.
'38. Classification der Batrachier mit Berucksichtigung der fossilen Thiere dieser Abtheilung der Reptilien. *Mem. Soc. Sci. Nat. de Neuchatel*, vol. 2.

WAGLER, JOH.

'30. Natürliches System der Amphibien mit vorgehenden Classification der Säugethiere und Vögel. München, Stuttgart und Tübingen.

WAITE, F. C.

'97. Variations in the Brachial and Lumbo-sacral Plex (uses) of *Necturus maculosus* Rafinesque. *Bull. Mus. Comp. Zoöl.*, vol. 31, pp. 69–92.

VOLVOX FOR LABORATORY USE

BERTRAM G. SMITH

In providing a supply of Volvox for class use late in the fall, difficulty has been experienced in two respects: in keeping the material alive in the laboratory as long as desired, and in getting specimens containing sperm and ova. Inquiry reveals the fact that others have had the same trouble. I have recently been able to overcome both these difficulties, and at the suggestion of Dr. H. H. Newman have recorded the method in some brief notes.

Species.—So far as known, the only species of Volvox that has been found in the vicinity of Ann Arbor during the late autumn is *Volvox aureus* Ehrenb. It is not very abundant, and I have never found it in the sexual stage at the time it was collected. It occurs in small glacial pools containing Riccia and duckweed.

During the early spring *Volvox globator* Linn., and no other species, occurs in great abundance in the same pools that later contain *Volvox aureus.* I have occasionally found it in the sexual stage when collected.

By the latter part of June *Volvox globator* has become quite scarce, and *V. aureus* has begun to appear. During the early part of July the two species exist in the same habitats, but neither is very abundant.

Since Volvox is so widely used for laboratory work by beginning classes, the marked specific differences are matters of importance. *Volvox globator* is the form described in text-books, but the description is far from being applicable to *V. aureus.* Since the latter may at times be the only species available, it may be profitable to call attention to the differences between the two species, for it is to be suspected that *Volvox aureus* is sometimes used without its species being recognized.

Volvox globator is considerably larger than *V. aureus*; its somatic cells are more numerous and compactly arranged. The somatic cells of *globator* are angular and connected by very stout protoplasmic strands; the somatic cells of *aureus* are round when seen

from the surface, and connected by very slender protoplasmic strands, difficult for students to make out under the microscope. *Volvox globator* is monœcious: in the sexual stage both sperm bundles and eggs may be found in the same colony at the same time. The number of sperm bundles in a single colony is small. *Volvox aureus* is either diœcious or monœcious proterogynous: sperm and eggs are never found together in a single colony at the same time, but the colony may contain one or the other exclusively. However, I have found daughter colonies, some of which contained bundles of sperms, others ova, within the same parent colony. The number of sperm bundles in a single colony is very large. *Sphærosira volvox* Ehrenb. is an old name for the male colony of *Volvox aureus.*

Kofoid ('99) gives the following key for the determination of the two species:

Cells about 10,000 (minimum 1,500, maximum 22,000), angular with stout connecting protoplasmic processes into which the chromatophore may enter. Diameter of colony about 700 μ (minimum 400, maximum 1,200); diameter of cell body 3–5 μ. *V. globator* L.

Cells 500–1000 (minimum 200, maximum 4,400); rounded, with slender connecting protoplasmic processes into which the chromatophore does not enter. Diameter of colony 170–180 μ; diameter of cell body 5–80 μ. *Volvox aureus* Ehrenb.

Klein ('99) gives illustrations of the general appearance of the two species, including reproductive stages. Meyer ('96) gives details of cell structure, with illustrations.

Volvox globator is probably a better form for laboratory work than *V. aureus*, and can be obtained in greater abundance if secured early in the spring. Hence if Volvox is to be studied in the fall by large classes it is well to preserve this species in 4% formalin in the spring; for many purposes the preserved material, if not kept too long, is as good as the living. The study of preserved specimens of *V. globator* can then be supplemented by the living *V. aureus.*

Keeping Volvox alive in the Laboratory.— Terry (:06) in experimenting on the galvanotropism of Volvox met with the usual difficulty in keeping it alive in the laboratory, and concluded that the organisms died of insufficient nourishment caused by improper

food supply and poor light, but found it impossible to regulate either so that they would live for more than four days. My own experience has convinced me that in our laboratory one of the principal causes of the death of the organism has been injurious mineral substances in the tap water in which the specimens were kept.

In collecting Volvox for our laboratory it has been customary to bring in considerable quantities of vegetable material (duckweed, Riccia, etc.) from the ponds in which Volvox occurred, along with a little water, and place this material in shallow glass dishes filled with tap water. As fast as the organisms gathered on the lighted side of the dish they were picked off and removed to a dish of clean tap water, it being deemed unsafe to leave them in the original dish exposed to the attacks of crustaceans. Suspecting that deleterious substances in the tap water, as well as the lack of a proper food supply, caused the death of the organisms, I made an attempt to reproduce the natural conditions. Water containing Volvox was brought in in considerable quantities, together with a small amount of the vegetable material, and placed in shallow glass dishes without the addition of tap water. The dishes were placed near windows and covered with glass plates to prevent loss of water by evaporation and to keep out bacteria and fungi, except that when exposed to direct sunlight it was found advisable to leave room for circulation of air between the cover and the dish to prevent a rise of temperature beyond the optimum. The water was not changed at any time during the course of the experiment. In the majority of the aquaria thus prepared, Volvox flourished for several weeks; in the fall of 1905, *Volvox aureus* was kept alive in several aquaria for from four to eight weeks; less success was attained with *Volvox globator* in the spring, but it was kept alive in most cases for about two weeks.

It was noted that *Volvox globator* clusters about decaying insect larvæ, perhaps on account of the presence of carbon dioxide. A moderate amount of decaying plant or animal material in the water seems to be one of the essential conditions for its existence. In its natural environment, Volvox is often found in decidedly stagnant water.

Temperature is an important factor to be considered in caring

for Volvox. It is more difficult to keep the material alive in the laboratory during warm weather because, in exposing the dishes to sunlight, the water is likely to become warmer than that of the ponds in which Volvox lives. This difficulty might be overcome by placing the dishes where they will be partly immersed in the running water of a shallow aquarium, and at the same time receive an abundance of sunlight.

In case organisms that feed upon Volvox are too abundant, the latter may be freed from its enemies by removing it with a pipette when clustered at the lighted side of the dish, to a dish of pond water strained through bolting cloth to remove crustaceans, etc.

Obtaining Volvox in the Sexual Stage.— Both in the fall and in the spring, material in the sexual stage was obtained in abundance merely by keeping the organisms alive in the laboratory. Several aquaria should be set up, and in some of them, specimens in the sexual stage will usually be found in the course of one or two weeks. It was noted by Dr. H. H. Newman that they often remain hidden in the ooze at the bottom of the dish. When they reach the sexual stage they seem to become less motile and consequently drop to the bottom. This is especially true of sperm colonies in *V. aureus.*

UNIVERSITY OF MICHIGAN
ZOOLOGICAL LABORATORY
ANN ARBOR, MICHIGAN

LITERATURE

KLEIN, L.
'99. Morphologische und biologische Studien über die Gattung Volvox. *Jahrb. f. wiss. Bot.*, vol. 20.

KOFOID, C. A.
'99. Plankton Studies, etc. *Bull. Ill. State Lab. Nat. Hist.*, vol. 5.

MEYER, ARTHUR.
'96. Die Plasmaverbindungen und die Membranen von *Volvox globator, aureus,* und *tertius,* mit Rücksicht auf die thierischen Zellen. *Bot. Zeit.* vol. 54, pp. 187–217.

TERRY, O. P.
:06. Galvanotropism in Volvox. *Am. Journ. Physiol.*, vol. 15, No. 3.

OSTRACODA FROM SOUTHEASTERN MASSACHUSETTS

JOSEPH A. CUSHMAN

That the Ostracoda of New England have been greatly neglected may at once be seen by a reference to Miss Rathbun's list of the New England Crustacea. At the time of its publication there was a single species reported from New England and that from but one locality. With a view to supplying this lack of records in a slight measure, some collecting has been done in our ponds, mainly about Boston. Several persons have kindly supplied material which has now been placed in the collections of the Boston Society of Natural History. Seven species are reported here, making the number of species now known from the fresh water of New England, nine instead of one. All of the records so far, however, are from Massachusetts.

It has been a matter of interest to find the local distribution of the species. Where a species is found at all it is usually abundant. Of the three species of Cypris reported, all were found in ponds in the vicinity of Boston and but a short distance apart, yet no one collection contained more than a single species.

A number of other species have been collected but in immature condition or in insufficient numbers for complete diagnosis.

The measurements given are average ones for the material examined. As a rule, if adults alone are taken there is a noticeable constancy in measurements but in cases where the collection contains the young also, the range in measurements is considerably greater.

It is to be hoped that more collecting will be done in the near future and over a much broader region. By this means a considerable addition to the present list should be made. The seven species representing five genera are given below.

Family *Cyprididæ*

Subfamily Cypridinæ

Genus SPIROCYPRIS Sharpe, 1903

1. **Spirocypris passaica** Sharpe

Length 1.54 mm., height 0.76 mm., breadth 0.78 mm.

Spirocypris passaica Sharpe, *Proc. U. S. Nat. Mus.*, vol. 26, 1903, p. 982, pl. 66, figs. 1–3.

This species and genus were described as new from material in the U. S. National Museum, collected at Passaic, New Jersey. There is no other record for it, as far as I know, up to the present. It is especially interesting, therefore, to be able to record this species from Massachusetts. Several specimens were obtained from Wellesley, Mass., April 20, 1905, collected by Mr. Irving L. Shaw.

The Massachusetts specimens were very slightly smaller than the types but otherwise the specimens agreed very well. The peculiar arrangement of the testes in concentric circles is very apparent and striking. The original description gives the furca as 23 times as long as wide. In the specimen measured from Massachusetts the length was 0.486 mm. and the breadth 0.021 mm. A closer ratio of 23:1 could hardly be obtained in such a structure. Further collecting may show this species to be widely distributed in New England.

Genus CYPRIS O. F. Müller, 1792

2. **Cypris virens** (Jurine)

Monoculus virens Jurine, *Histoire des Monocles, qui se trouvent aux Environs de Genève*, 1820, p. 174, pl. 18, figs. 15–16.

Cypris virens Zaddach, Synopseos Crustaceorum Prussicorum Prodromus, 1844, p. 35.

Length 1.70 mm., height 0.97 mm., breadth 0.90 mm.

Arlington, Mass. May 7, 1905. A. S. Pearse, coll.

This is a very widely distributed species and should be found throughout New England as collecting is extended. It was represented in considerable numbers in the material examined.

3. **Cypris fuscata** (Jurine)

Monoculus fuscatus Jurine, *l. c.*, 1820, p. 174, pl. 19, figs. 1, 2.
Cypris fuscata Zaddach, *l. c.*, 1844, p. 32.

Length 1.36 mm., height 0.81 mm., breadth 0.75 mm.

Near Fresh Pond, Cambridge, Mass. April 30, 1905. J. A. C., coll.

In a very shallow pond-hole this species was very abundant on the date given. As in the case of the preceding species, this is very widely distributed and should be found throughout New England.

4. **Cypris reticulata** Zaddach

Cypris reticulata Zaddach, *l. c.*, 1844, p. 34.

Length 1.20 mm., height 0.70 mm., breadth 0.60 mm.

Brookline, Mass. April 10, 1905. Irving L. Shaw, coll.

Although this species is a very characteristic one and is widely distributed in Europe, its occurrence in this country has hitherto rested upon the single record of Dr. Sharpe. He found it in great numbers at Normal, Ill., in a small grassy pool. It seems to prefer such a habitat and therefore may be looked for in New England in such places. The species was abundant in the collection from Brookline.

Subfamily Cypridopsinæ

Genus Cypridopsis Brady, 1868

5. **Cypridopsis vidua** (O. F. Müller)

Cypris vidua O. F. Müller, *Entomostraca seu Insecta testacea, quae in aquis Daniae et Norvegiae reperit, descripsit et iconibus illustravit*, 1792. p. 55, tab. 4, figs. 7–9.

Cypridopsis vidua Brady, "A Monograph of the Recent British Ostracoda," *Trans. Linn. Soc. London*, vol. 26, pt. 2, 1868, p. 375, pl. 24, figs. 27–30, 46.

Length 0.64–0.75 mm., height 0.38–0.42 mm., breadth 0.42–0.47 mm.

Small pond, West Cambridge, Mass. April 30, 1905. J. A. C., coll.

In tap water from Fresh Pond, Cambridge, Mass. Aug. 12, 1905. A. S. Pearse, coll.

Cohasset, Mass. Oct. 22, 1906. Owen Bryant, coll.

This species should be found everywhere in all kinds of fresh water. It is probably the most abundant and one of the most widely distributed of our fresh-water ostracods. It may be overlooked on account of its small size.

Subfamily Cyclocypridinæ

Genus Cypria Zenker, 1854

6. **Cypria exsculpta** (Fischer)

Cypris exsculpta Fischer, "Beitrag zur Kenntniss der Ostracoden," *Abhandl. math. phys. Klasse k. bayr. Akad. d. Wiss.*, vol. 7, 1855, p. 18, pl. 19, figs. 36–38.

Cypria exsculpta Brady and Norman, "Monograph of the Marine and Freshwater Ostracoda, Sec. I," *Trans. Roy. Dublin Soc.*, ser. 2, vol. 4, 1889, p. 68, pl. 11, figs. 1–4.

Length 0.68 mm., height 0.44 mm., breadth 0.28 mm.

Woods Hole, Mass. Abundant in fresh-water pond, June 25, 1905, A. S. Pearse, coll. July 15, 1906, J. A. C., coll. Auburndale, Mass., Oct. 28, 1906, C. W. Johnson, coll.

This species is almost as widely distributed and abundant as the preceding. It should be found throughout New England.

Subfamily Candoninæ

Genus Candona Baird, 1850

7. **Candona candida** (O. F. Müller)

Cypris candida O. F. Müller, *l. c.*, 1792, p. 62, tab. 6, figs. 7–9.

Candona candida Lilljeborg, *De Crustaceis ex ordinibus Tribus*, 1853, p. 127, pl. 11, figs. 19–20, pl. 25, figs. 13–15.

Length 0.86–1.39 mm., height 0.45–0.66 mm.

Arlington, Mass., May 7, 1905, A. S. Pearse, coll.; Auburndale, Mass., Oct. 28, 1906, C. W. Johnson, coll.

This species has not been reported from America as far as I am aware. The specimens seem to agree well with the European

figures and descriptions and seem to be that species without doubt. There is a very considerable range in the measurements given as many young specimens and both sexes were in the lot measured. An average measurement would be close to the maximum given here, if adults alone were taken.

This species, like the others of its genus, has a crawling habit and may be in this way overlooked in collecting and in the examination of fresh material. It was not abundant in either of the two collections in which it was found.

Boston Society of Natural History, November, 1906.

NOTES AND LITERATURE.

PHYSICS.

A First Course in Physics.[1] — These two books outline a thoroughly substantial course in elementary physics. They are obviously intended to be used together, but each is complete in itself and either (preferably the laboratory manual, as the authors themselves say in their preface) could be used alone as the basis of a shorter course.

The essential feature of these books is their emphasis on the necessity of showing a student "the hows and whys of the physical world in which he lives" as well as the "how much" to which the reaction from "the superficial, descriptive physics of thirty years ago" has led us. For this reason, a great number of devices which are in common use are explained with the help, in many cases, of admirable diagrams of actual machines; as examples we may mention platform scales for wagons, gas meters, two kinds of hydraulic elevators, the fire engine, the railroad locomotive, hydraulic and steam turbines and gas engines, artificial-ice and liquid-air machines, an excellent discussion of the modern methods of heating and ventilating houses, a full description not only of the instruments used in telegraphy and telephony, including the carbon transmitter, but also of the circuits themselves, including even the new Bell central-battery system of telephony, automatic signals and all, three pages of musical instruments, the Zeiss binocular and, of course, wireless telegraphy. In the present instance, the introduction of these illustrative digressions is governed by so just a sense of proportion, and they are handled so well and are backed by so much thoroughly good physics of a more quantitative sort, that the result is much to be commended. It should always be remembered, however,— this is to be taken not as a criticism but as a warning — that this sort of thing may very easily become, in the hands of authors and especially of teachers less scholarly than Professor Millikan and Dr. Gale, an unfortunate return to the old-fashioned superficial, descriptive "natural philosophy" which they themselves so definitely deplore.

[1] Millikan, Robert Andrews and Gale, Henry Gordon. *A First Course in Physics.* Boston, Ginn & Co., 1906. 8vo, viii + 488 pp.

Millikan, R. A. and Gale H. G., *A Laboratory Course in Physics, for Secondary Schools.* Boston, Ginn & Co., 1906. 8vo, x + 134 pp.

Another interesting feature of these books is the free use which is made in qualitative explanations of such conceptions as the kinetic theory of gases, the ionic theory of electrolytic conduction, and the wave front in geometrical optics. Whether or not it pays, for instance, to displace the old ray-optics, which must, of course, be properly interpreted, by the more valuable but also more difficult notion of the wave front, is a question of pedagogy which each teacher must decide for himself. Fortunately the treatment of the most dangerously spectacular part of our modern physics is confined to the last twelve pages of the text-book, where there is an account, admirable as regards both interest and conservatism, of vacuum tube phenomena and of radio-activity, including some of the evidence for the existence of electrons, together with brief statements of the corpuscular theory of matter and of the disintegration theory of radio-activity.

Many other features, while not unique, are nevertheless worthy of much praise. For instance, the experiments, both for the laboratory and for the lecture room, are ingeniously simple and yet, so far as one can judge without trying them, entirely effective.

The typography is good, and the illustrations are most excellent, both in technique and in conception; and the sixteen full-page halftones of eminent physicists, each with a short paragraph describing the man's life and work, are a notable addition not only to the attractiveness but to the real value of the books.

H. N. D.

BIOLOGY.

Jennings' Behavior of the Lower Organisms.[1]— It is now nearly a decade since Professor Jennings published his first brochure on the reactions to stimuli in unicellular organisms. The intervening period has been one of continuous activity on his part in the study of animal behavior, especially among the lower organisms. His investigations have not been strictly confined to the Protozoa for among the score or more of titles of important contributions from his

[1] H. S. Jennings. *Behavior of the Lower Organisms.* Columbia University. Biological Series, New York, The Macmillan Co., 1906, 8vo, xiv+366 pp., illus. $3.00.

pen are studies of the reactions of Metridium and of rotifers. Nor have his investigations been limited to the animal world alone for groups on the border lines such as the flagellates and bacteria have also been included. All students of these groups and especially investigators of animal behavior and workers in the field of comparative psychology will find cause for congratulation in the fact that Professor Jennings has taken this opportunity to resurvey the whole field of his experimental work and to summarize and restate his conclusions in this most important field of research. While many studies in this field have been made primarily from the standpoint of the psychologist, or have been of a desultory character, or are but partial in scope, the work summarized in this book has been dominated by the broadest scientific spirit, has been conducted with the greatest care and thoroughness, has included in its scope all possible avenues of approach to the analysis of animal behavior, as exemplified in the simplest organisms, and has been carried through to a stage of completion where fundamental generalizations are possible. The work of others in this field whether in agreement or not, with the author's conclusions, is treated with fullness and fairness. The book thus becomes an exemplification of the value of intensive research, an indispensable authority for any who wish to become familiar with the latest results in the field of animal psychology. As illustrative of the thoroughness with which the analysis has been carried out we find that in Paramecium the structure and the normal movements are described and correlated, and the reactions to chemical and mechanical stimuli of various sorts determined, the absence of reaction to light but the sensitiveness to the ultra-violet rays noted, as are also the reactions to heat and cold, to induction shocks and a constant current of electricity, to water currents, gravity, and centrifugal force. The relation of these actions of orientation to other reactions is carefully analyzed. The behavior of Paramecium in daily life in the aquarium, in fission and conjugation, under two or more stimuli, are all passed in review and the variability and modifiability of reactions is determined. The author concludes from observations on the differences in behavior of individuals that we find in Paramecium slight beginnings of the modification of behavior through the previous experiences of the organism. In the case of Stentor the same individual does not always behave in the same way under the same external conditions, but the behavior depends upon the physiological condition of the animal. The reaction to any given stimulus is modified by the past experience of the animal, and the modifications are regulatory, not

haphazard, in character. The phenomena are thus similar to those shown in the "learning" of higher organisms, save that the modifications depend upon less complex relations and last a shorter time.

Each organism is found to exhibit a set of actions made up, in the case of the lower organisms, of a few factors combined in various ways in a coördinated system which Professor Jennings designates as "the action system." For the term "motor reaction" employed in his earlier papers the phrase "avoiding reaction" is now used to designate the stereotyped method of reaction of Infusoria to most stimuli. The author rejects the local action theory of tropisms as a "more or less artificial construction, made by combining certain elements of behavior and omitting others that are of most essential significance." In its place he proposes the method of "trial and error" as an explanation of behavior. The stimulus interferes with definite internal processes occurring in the organism and this interference causes a change in behavior and varied movements which subject the organism indiscriminately to many different conditions. It merely acts in all sorts of ways possible to it. When one of these new conditions thus met relieves the organism from the existing interference with its life processes, the trials cease.

As a second cornerstone in the formulation of behavior we find the law of "resolution of physiological states" thus stated: "The resolution of one physiological state into another becomes easier and more rapid after it has taken place a number of times." It appears that even in Stentor and Vorticella repetition of an action brings the second step in a sequence in behavior more quickly upon the first. Here lie the foundations of the phenomena which are usually designated as habit formations, memory and learning, and the question may well be asked whether they are not coëxtensive with life and based fundamentally on the physical and chemical structure of colloids.

C. A. K.

Modernized Darwinism.[1] — Professor Guenther has written a very readable book on Darwinism and allied biological problems which the tyro will find quite intelligible. The translation seems good and the publishers have done their part well. The treatment of the subject is rather novel, most of the chapters being divided tax-

[1] C. Guenther. *Darwinism and the Problems of Life.* Translated from the third edition by Joseph McCabe. London: A. Brown & Co., 1906, Dutton & Co., New York, American agents. 8vo, 439 pp.

inomically under the headings mammals, birds, reptiles, and amphibians, etc. The group names, however, merely serve as hooks on which to hang certain biological discussions. Thus, under mammals are considered: protective coloration of hairy coats, hibernation, play of animals; under birds, sexual selection and migration; under reptiles and amphibians, the death of species and the origin of aërial life; under fishes, the origin of terrestrial vertebrates, rudimentary organs, and the biogenetic law; under insects, mimicry, instincts, inheritance of acquired characters; under crustaceans and molluscs biochemistry, parthenogenesis, and the meaning of sexual reproduction; under worms and cœlenterates, the descent of animals, parasitic life and symbiosis; under Protozoa, the principle of division of labor, the origin of the germ cells, and outlines of a theory of heredity. This arrangement does not lend itself to a systematic and logical development of the subject but the result is easy and delightful reading.

Not only is the book interestingly written but it is also a perfectly safe one. No evolutionary heresies tarnish its pages; nothing but simon-pure, orthodox natural selection is permitted here. Of course, as befits a scientific book, reference is made to de Vries's mutation theory and that of orthogenesis. The former is quickly disposed of in a couple of pages by stating first, that it cannot account for adaptations because with each mutation many or all parts change and all the changes cannot be adaptive. Secondly, an arising mutation will be swamped by intercrossing with the original stock. "Hence the multiplicity of our actual species cannot be due to mutations." Now that we know that species *cannot* be due to mutations it is to be hoped that people will please stop speaking about them. Similarly in regard to orthogenesis the theory is stated in one paragraph and then — "we need not delay long with this theory, because we know that the foundation of it is unsound." Thus authority speaks and an obedient scientific world will quickly forget that the theory was ever held by anyone. The folly of any other theory of evolution than Darwinism of the Weismannian brand is overwhelmingly demonstrated in every chapter by persuasive arguments and appealing examples. The necessary limitations of natural processes are so clearly set forth that the investigator has only himself to blame if he wastes time investigating any other theories of evolution; for, has not the author shown that they are all impossible?

C. B. D.

Momentum in Variation.— It is a little late to criticize an article that appeared in November, 1905, nevertheless I should like to say a word or two in regard to the paper by Mr. F. B. Loomis entitled "Momentum in Variation." The conclusion is reached that a variation started along any line tends to carry that line of development to its ultimate, being driven by momentum. If the feature is detrimental, the group dies out. If, however, it is merely a minor feature, it makes a handicap.

No one doubts that in the course of evolution, specialization goes so far as to carry a given species or group out of existence, but that this is of such widespread occurrence as Mr. Loomis implies, is open to doubt. Certainly the statements which he adduces to support this theory, are in many cases erroneous and in other instances open to quite other deductions than are placed upon them.

The few comments here given, are not at all in the line of captious criticisms, but are merely intended as a protest against any such short-cut to a solution of important problems as that taken in the paper in question.

If we begin with the Saber-toothed Tigers, which are cited as examples of extinction due to overdevelopment, we may go back about twenty years to the time when Professor Cope reached a similar conclusion, saying in the course of some discussion that Smilodon undoubtedly became extinct because it could not obtain food, whereupon someone present arose and said: "Mr. Cope, what did the Smilodon feed on"? In connection with this Dr. Matthew has recently brought forward some facts tending to show that the long tusks of Smilodon were of service in cutting through the long hair and thick hide of some of the contemporary ground sloths. Certainly if the tusks of Smilodon caused its extinction, why does not the Walrus die out for a similar cause? The Mammoth with its extreme development of tusks is also cited to illustrate the principle of momentum in variation, leading to extermination, but the great Gangetic elephant which shows the most enormous development of tusks, became extinct long ago, while other members of the race whose tusks were far more recurved lived on. Nor did those mastodons in which the tusks were greatly curved, come to an untimely end one whit sooner than their contemporaries with fairly straight tusks. The African Elephant, which is much the most primitive in structure of existing species, and more nearly resembles *E. ganesa* in tusk development, is the species that has thrived best. Moreover, the African elephant is the one in which tusks are present in both sexes while a large proportion of the

females of Asiatic Elephants are tuskless, so that here we have a case in which tusk development has gone beyond sex differentiation.

If Babirussa seems to be handicapped by its teeth, though there is another side to the case, how about Mesoplodon, in one species of which the teeth lock over the beak so that the animal can open its mouth for a short distance only and yet shows no signs of passing out of existence.

The elongation of the snout of Teleosaurus is cited as another disadvantageous character but the Gangetic Gavial in which the snout is nearly as long, finds this of great service in catching fish, as undoubtedly Teleosaurus did, and Dr. Abel gives elongation of snout as characteristic of fresh-water cetaceans.

Stegosaurus did not come to an end on account of its heavy armor but from some other cause, for the active predatory dinosaurs, such as Allosaurus, that were unincumbered by any defensive armor, died out just as did their heavier-plated contemporaries. The male Narwhal which has a single long tusk lives in the same sea and just as long and happily as his tuskless spouse, and many similar instances might be cited. The problem of the extinction of animals is far too complicated to be decided in haste and few of the examples cited by Mr. Loomis seem to be conclusive.

F. A. Lucas

Xenia in Wheat.[1] — As everyone has noticed, when white sweet corn is pollinated with red corn the outer part of the grains, although not truly part of the embryo, is red. This is a case of so called xenia. Xenia has been observed in other cases also, notably in beans and in wheat. Tschermak has recently studied xenia in wheat in more detail. He experimented with two races — the Hanna wheat and the Petkus wheat. Both kinds of wheat when in bud yield both green and yellow seeds; but yellow Hanna wheat gives 80% of yellow grains and green Petkus wheat breeds almost pure (95% of green seeds). The green Hanna and the yellow Petkus wheats when inbred yield only about half of their own kind respectively. Tschermak finds that when green and yellow Hanna wheats are cross-bred the seeds resulting show the color of the mother stock, whichever is so used. Likewise when the green and the yellow Petkus wheats are crossed

[1] Tschermak, E., "Ueber Züchtung neuer Getreiderassen mittels Künstlicher Kreuzung, II." *Zeitschr. f. d. landw. Versuchswesen in Œsterreich*, 45 pp., Feb., 1906.

the seeds have only the maternal color. On the other hand, when the opposite colors are derived from different races, and, especially, when the father is either yellow Hanna or green Petkus, the paternal character shows strongly on the seeds. Consequently, xenia is better manifested in wheats that are not very closely related than in those that are.

C. B. D.

ZOÖLOGY

Folsom's Entomology.[1] — Dr. Folsom's new work occupies a unique place among entomological text-books. As stated in the preface, "the book was written in an effort to meet the growing demand for a biological treatment of entomology." To this end the systematic side of the subject has been confined to a mere outline of the orders, following essentially the system of Brauer. The external anatomy, too, has been very briefly touched upon as that has been emphasized by the current texts.

On the other hand, there is an admirably clear-cut discussion of the elements of internal anatomy and of physiology. The value of this chapter lies not only in the careful organization of the material presented but in the omission of a vast amount of detail. The author has followed a common error in stating that the alary muscles are unstriated. He speaks of the follicular cells of the ovary as derived from the primitive germ cells,— a view which is not held by recent investigators of this subject. In view of the decisive work of Petrunkewitsch and other of Weismann's students one is surprised to see, p. 145, the statement that "males may, of course, result from fertilized eggs, as in the honey-bee, according to Dickel."

The chapter on development likewise shows the virtue of vigorous pruning. There is a very brief but excellent outline of the embryological development, while the greater portion of the chapter is devoted to the postembryonic development.

[1] Folsom, J. W. *Entomology, with Special Reference to its Biological and Economic Aspects*. Philadelphia, Blakiston's Son & Co., 1906. 8vo, vii + 485 pp., with 1 col. pl. and 300 illustrations.

The remainder of the text is largely devoted to biological phases of the subject. Much material which is not accessible in any other text is here brought together and is treated from a broad biological view-point. The subjects of color and coloration; the origin of adaptations and of species, distribution; the relation of insects to plants and to other animals; their interrelations and their behavior, are treated in a concise but most readable and interesting manner.

Though the method of treatment is professedly economic as well as biologic, the practical aspect of the subject receives but scant attention. The relations of insects to plants, and to other animals, are discussed from the view-point of the biologist. Six pages are devoted to an excellent summary of the important subject of the transmission of disease by insects. The sixteen pages on insects in relation to man are largely given over to a statement of the importance of the subject and to an historical sketch of the progress of economic entomology in America.

The illustrations are excellent and, in many cases, new and prepared by the author. Such as have been copied are very carefully credited. An extensive and carefully arranged bibliography will be very helpful to the student.

Dr. Folsom is to be congratulated on the clear, concise, and interesting presentation of his material. The book is one which is bound to prove stimulating, and which every worker in the field of entomology and every teacher of zoölogy will want in his own library. Whether it will meet the present day demands for an entomological text-book is a question.

W. A. R.

Additional Observations on Hyla andersonii and Rana virgatipes in New Jersey.—An effort was made this past summer to add to the observations on *Hyla andersonii* and *Rana virgatipes* published in two previous numbers of the *American Naturalist.*

It was observed in June at Lakehurst that the males of *Hyla andersonii* were attracted to a few small pools in particular, several of which were only a yard or two in diameter. On July 21st, with Mr. James Chapin, I made search in these pools for the tadpoles, and was fortunate in finding a number in one pool, though they appeared to be absent from another and similar locality about a mile distant where the adult frogs had been and were still most numerous. The tadpoles collected were in all stages from a few millimeters long to those just leaving the water as little frogs. The mature tadpoles are from 35 to 40 mm. long and of the usual tadpole color, that is, of the color of the

muddy bottom of a pool. The under parts are lighter and show a golden sheen, which sometimes extends up the sides. The small hind legs show early on the ends of the toes the disks that are so conspicuous in the mature Hyla. The tail is spotted, and there is usually a dark irregular marginal band. The maculations sometimes become irregular blotches as on the tails of the tadpoles of *Hyla versicolor*. When the tail is nearly absorbed, and they leave the water, they are about 25 mm. long and of a dull olive green. They grow lighter, that is, brighter green in hue with the disappearance of the tail, until the little frogs, which in length of body are 15 mm., resemble the mature individuals. The white that margins the green of the back and extremities is not so conspicuous as in the adults, and the saffron of the under parts is wanting in those that I have examined. The narrow band of purplish brown that commences at the nose and extends through the eyes and so down the sides is conspicuous in the little frogs before the last remnant of the tail has disappeared.

The adult *Hyla andersonii* is amusingly active at night and jumps about the lower limbs of the trees and on to the bushes with much agility. They seem rarely to climb over five or six feet from the ground. They sit upright and look pert, and if interrupted in the midst of their song they leave their bubbles blown up until such time as the intruder goes away or stands still. In the day time they are usually quiet and for the most part hide in the damp moss and leaves lying on the ground.

On the warm cloudy evening of August 10th, *Hyla andersonii* was heard near some pools a short distance north of the village of Farmingdale, N. J. This locality is 15 miles northeast of Lakehurst, which has been the most northern locality for the frog heretofore recorded.

Rana virgatipes may be called the Carpenter Frog, for its note sounds much like the blow of a hammer on a board. It is a quickly uttered *chuck-up, chuck-up*, and the frog usually hammers from three to four times. For a time I was not sure of the singer, but some captive individuals under the influence of good living have uttered this call-note in my room while I sat by. These frogs domineer over one another to some extent, and when insects were placed in the cage as food, it was common for the more active individual, failing in the attempt to catch a fly, to turn on his companion and butt him until he retreated into the pool or into a corner. The butted individual would hold his head down in the meekest manner, and he became so cowed that if I touched him at any time with my finger, he assumed the humble position. Miss Dickerson in *The Frog Book* says that

Rana pipiens and *Rana onca* will snap at the head of a companion frog that has taken a worm that he was trying to capture, but she thinks it is probably not an exhibition of anger, but a desire to secure the disappearing worm. However this may be, it is certain that the butting *Rana virgatipes* in the above-mentioned case secured a great advantage over the other frog, for after "settling" his companion, he captured all of the insects.

WILLIAM T. DAVIS

Zoölogical Laboratory Notes.— In the form of loose leaves bound together so that they can be individually removed, T. H. Sheffer[1] has prepared a set of laboratory notes on about two dozen common animals. Such notes are usually so arranged as to excite in the student a desire to study the material before him; this set described rather fully what he "ought" to see and is well calculated to kill any real growing interest he may have. The author thinks the notes should commend themselves to teachers "by reason of certain special advantages and a simple and rational treatment in general."

Notes.—*Circulatory Organs of Diotocardian Gastropods.* The study of the heart of the diotocardians by Spillmann ("Zur Anatomie und Histologie des Herzens und der Hauptarterien der Diotocardier." *Jen. Zeitschr. f. Naturwiss.*, vol. 40, pp. 537–538, pls. 19–21) justifies the separation of the Rhipidoglossa from the Docoglossa. In the Rhipidoglossa the pericardial chamber is penetrated by the intestine, and there are two auricles. While the auricles are thin-walled and deficient in muscle, the ventricle has a thick muscular wall of three layers. The openings from the auricles to the ventricle are guarded by lamellar valves. In the Docoglossa the intestine does not penetrate the pericardial chamber, and only the left auricle is present. This has the same structure as in the Rhipidoglossa, but the ventricle of the Docoglossa shows only two of the three layers seen in the Rhipidoglossa. In the Docoglossa the opening from the auricle into the ventricle is provided with a tubular valve. Nerita forms an interesting transition between these two groups so far as the structure of its heart is concerned. It may be called a docoglossan with a penetrated pericardial chamber or a rhipidoglossan with lamellar valves.

Goblet Cells in the Epidermis of Fishes. According to Oxner

[1] Scheffer, T. H. *The Loose Leaf System of Laboratory Notes.* P. Blakiston's Son & Co., Philada., 1906, 112 pp.

("Ueber die Kolbenzellen in der Epidermis der Fische." *Jen. Zeitschr. f. Naturwiss.*, vol. 40, pp. 589–646, pls. 22–26) goblet cells occur in the epidermis of cyclostomes and most physostomous teleosts. All goblet cells are modified epithelial cells from the deepest or germinal layer of the epidermis. They are undoubtedly specialized unicellular glands which may have in addition some supporting function.

The Selachian Eye. From a study of the eyes of some eighteen species of sharks and rays Franz ("Zur Anatomie, Histologie, und functionellen Gestaltung des Selachierauges.' *Jen. Zeitschr. f. Naturwiss.*, vol. 40, pp. 697–840, pl. 29), has shown that while there are many specific differences, the eyes of this group as a whole are clearly distinguishable from those of other vertebrates. What is especially peculiar in them is the tapetum lucidum, an epithelial musculature in the iris instead of the usual mesodermal one, a specialized zonula zinnii, and the absence of a falciform process characteristic of other fishes. The adaptations shown by the eyes of different species are discussed at some length.

G. H. P.

BOTANY

Bergen and Davis's Principles of Botany.[1] — One of the most successful American elementary botanical text-books has been Bergen's *Foundations of Botany.* With its author, Dr. Davis has been associated in the preparation of the present book, which is certain to find favor with the users of its predecessor and to win many new friends since in addition to what was best in the earlier text there is now given a consecutive series of studies of representative spore plants so treated as to outline the evolutionary history of the plant world. Both authors are experienced teachers, and also familiar with research problems at first hand, and they have brought to their task unusual care in grouping and handling the subject matter and in well illustrating it.

The book is said to furnish material for a full year's work. It contains, indeed, enough to occupy considerably more than this time,

[1] Bergen, J. Y., and Davis, B. M. *Principles of Botany.* Boston, Ginn & Co., 1906. 12mo, ix + 555 pp., 14 pl., 402 figs.

if all of its topics were thoroughly worked over; but the purpose of its authors has been to present somewhat more than is likely to be used, so that individual teachers may find it comprehensive enough to base on it courses adapted to their several needs. It is safe to say that it will be a much consulted book even in laboratories where other manuals are used to outline the courses given.

W. T.

Rydberg's Flora of Colorado.[1] As a precursor to his flora of the entire Rocky Mountain region, Dr. Rydberg has prepared a manual of the Pteridophytes and Spermatophytes of Colorado, which, for extent and carefulness of work stands well to the front among our State floras. Forty-nine orders, 134 families, 702 genera, and 2912 species find representation in it. The nomenclature used is essentially after the Philadelphia Code. Generic limits are confessedly rather radically close, and the same may be said of the limitation of species. Apparently good keys are given for the higher groups, genera, and species; but descriptions are limited to these, though ample data are given as to habitat, distribution, etc., and considerable synonymy is added.

W. T.

Notes: — The recently issued fifth volume on the Congress of Arts and Science, held in connection with the Louisiana Purchase Exposition of 1904, (Boston and New York, Houghton, Mifflin & Co., 1906) deals with Biology, Anthropology, Psychology and Sociology, and contains the following addresses of botanical interest: — Coulter, "Development of Morphological Conceptions"; Loeb, "The Recent Development of Biology"; De Vries, "A Comparison between Artificial and Natural Selection"; Bower, "Plant Morphology"; Goebel, "The Fundamental Problems of Present Day Plant Morphology"; Wiesner, "The Development of Plant Physiology under the Influence of the Other Sciences"; Duggar, "Plant Physiology — Present Problems"; Arthur, "The History and Scope of Plant Pathology"; Waite, "Vegetable Pathology an Economic Science"; Drude, "The Position of Ecology in Modern Science"; Robinson, "The Problems of Ecology"; Jordan, "Relations of Bacteriology to Other Sciences"; Smith, "Some Problems in the Life History of Pathogenic Micro-Organisms."

[1] Rydberg, P. A. "Flora of Colorado." *Bulletin 100, Agricultural Experiment Station of the Colorado Agricultural College*, Fort Collins, Col., 1906. 8vo, xxii + 447 pp.

The second volume of *Postelsia*, the Yearbook of the Minnesota Seaside Station, issued from the Pioneer Press of St. Paul, contains the following papers: — Rosendahl, "Observations on Plant Distribution in Renfrew District of Vancouver Island"; Butters, "The Conifers of Vancouver Island"; Evans, "Hepaticæ of Vancouver"; Hone, "Some Western Helvellineæ"; Griggs, "*Renfrewia parvula*, a New Kelp from Vancouver Island"; Henkel, "A Study of Tide-pools on the West Coast of Vancouver Island"; and Hall, "Some Geological Features of the Minnesota Seaside Station."

The weaving of stem and branches into a pseudo-trunk, by their aërial roots, is described and figured for Hemitelia by Schoute in vol. 20, part 2, of the *Annales du Jardin Botanique de Buitenzorg*.

An illustrated paper on the medullary rays of Conifers, by Tassi, forms part of the recently issued vol. 8, fasc. 1–4, of the *Bullettino del Laboratorio ed Orto Botanico* of the University of Siena.

An illustrated paper on the leaf structure of certain New Zealand plants, by Miss Herriott, is published in vol. 38 of the *Transactions and Proceedings of the New Zealand Institute*, which also contains other papers of botanical interest.

A study of unlignified cellulose in certain wood cells, and of the cellulose skeleton remaining after the delignification of others, is separately issued by Spaulding from the 17th *Annual Report of the Missouri Botanical Garden*.

Non-nitrogenous food reserves, and irritability, occupy a large part respectively of the recently issued first and sixth volumes of the *Recueil de l' Institut Botanique Léo Errera*, of the Brussels University.

Part 11 of Koorders & Valeton's "Additamenta ad Cognitionem Floræ Arboreæ Javanicæ" has recently been issued at Batavia as no. 2 of the *Mededeelingen uitgaande van het Departemente van Landbouw*.

An account of the botany of Christmas Island, by Ridley, is contained in the recently issued no. 45 of the *Journal of the Straits Branch of the Royal Asiatic Society*.

Considerable attention is given to Natural History in Sir Harry Johnston's book on Liberia (London, Hutchinson & Co., 1906, 2 vols.), an appendix on the flora being contributed by Stapf.

A number of generic segregates are published by Greene in the signature of his *Leaflets* issued on September 8th.

A considerable part of the June number of the *Revista de la Facultad de Agronomia y Veterinaria* of the La Plata University is occupied by an illustrated account of *Ilex paraguayensis* and its commercial preparation, by Uzal.

Ribes viburnifolium is figured in *Curtis's Botanical Magazine* for September.

A further discussion of *Primula obconica* and its poison, with figures of the glandular hairs, is contributed by Weydahl to *Gartenflora* of Sept. 1.

An illustrated monograph of the typical varieties of *Nicotiana tabacum* by Anastasia, has been issued from the *R. Instituto Sperimentale Tabacchi*, of Scafati, Italy.

Sprenger briefly describes his hybrids of *Yucca aloifolia* in the *Bullettino della R. Società Toscana di Orticultura* for August.

A fine flowering mass of *Yucca recurvifolia*, as grown at Kew, is figured in the *Gardeners' Chronicle* of August 18.

A sumptuous quarto volume on American fossil Cycads, by Wieland, has been issued as *Publication no. 34* of the Carnegie Institution of Washington.

A paper on the cytology of Entomophthoraceæ, by Riddle, forming no. 63 of the "Contributions from the Cryptogamic Laboratory of Harvard University," occupies vol. 42, no. 10, of the *Proceedings of the American Academy of Arts and Sciences.*

A number of new Philippine ferns are described and figured by Copeland in vol. 1, supplement 2, of *The Philippine Journal of Science*, issued on June 15.

Palmer contributes a paper on the nature of Diatom motion to vol. 1, no. 4, of the *Proceedings of the Delaware County Institute of Science*, of Media, Pa.

Papers on chromogenic fungi which discolor wood, and the zonation of artificial cultures of certain moulds, by Hedgcock, have been separately issued from the *17th Annual Report of the Missouri Botanical Garden.*

An illustrated synopsis of Portuguese galls is given by Tavares in *Broteria*, vol. 4.

The dune-fixing planting of Cape Cod is illustrated by Birge in *The American Inventor* for September.

An illustrated forestal account of Sequoia is given by Sterling in *School Science and Mathematics* for October.

A series of "Botaniker Porträts," each accompanied by a short but comprehensive biographic sketch, is being issued in quarto fascicles by Dörfler of Vienna. Judging from the two fascicles thus far issued, the quality of execution and accuracy of text are unimpeachable.

Kellogg contributes a paper on the scientific aspects of Luther Burbank's work to *The Popular Science Monthly* for October.

PUBLICATIONS RECEIVED

(Regular exchanges are not included)

BERGEN, J. Y., AND DAVIS, B. M. *Principles of Botany.* Boston and New York, Ginn and Co., 1906. 12mo, ix + 555 pp., illus. $1.50.— GUENTHER, C. *Darwinism and the Problems of Life. A study of Familiar Animal Life.* London, A. Owen and Co., 1906. 8vo, 426 pp.— HOLDER, C. F. *Half Hours with Fishes, Reptiles, and Birds.* New York, American Book Co., 1906. 12mo, 255 pp., 244 figs. 60 cts.— HOUGH, T., AND SEDGWICK, W. T. *The Human Mechanism, its Physiology and Hygiene and the Sanitation of its Surroundings.* Boston, Ginn and Co., 1906. 12mo, ix + 564 pp., illus.— HOWE, R. H., JR., AND M. A. *Common and Conspicuous Lichens of New England. A Fieldbook for Beginners. Part IV.* Boston, W. B. Clarke and Co., 1906. 16mo, pp. 57–71, illus. 50 cts.— INGERSOLL, ERNEST. *The Life of Animals. The Mammals.* New York, the Macmillan Co., 1906. 8vo, xi + 555 pp., illus.— JENNINGS, H. S. *Behavior of the Lower Organisms.* New York, The Macmillan Co., 1906. 8vo, xiv + 366 pp., illus. $3.00.— LINVILLE, H. R., AND KELLY, H. A. *A Text-book in General Zoölogy.* Boston, Ginn and Co., 1906. 12mo, x + 462 pp., 233 text-figs. $1.50.— MILLIKAN, R. A., AND GALE, H. G. *A Laboratory Course in Physics for Secondary Schools.* Boston, Ginn and Co., 1906. 12mo, viii + 134 pp., illus.— MONTGOMERY, T. H. *The Analysis of Racial Descent in Animals.* New York, Henry Holt and Co., 1906. 8vo, xi + 311 pp.— SKEAT, WM. W., AND BLAGDEN, C. O. *Pagan Races of the Malay Peninsula.* New York, The Macmillan Co., 1906. 8vo, 2 vols., xl + 724, x + 775 pp., illus. $13.00.— WRIGHT, C. T. *Field, Laboratory, and Library Manual in Physical Geography.* Boston and New York, Ginn and Co., 1906. 8vo, xii + 178 pp. + 164 pp. of ruled sheets. $1.00.

ADAMS, G. E., AND WHEELER, H. J. Continuous Corn Culture. *R. I. Agric. College*, bull. 113, pp. 99–114.— BARBER, H. G. Hemiptera from Southwestern Texas. *Sci. Bull. Mus. Brooklyn Inst. Arts and Sci.*, vol. 1, no. 9, pp. 255–289.— BARTSCH, P. The Urocoptid Mollusks from the Mainland of America in the Collection of the United States National Museum. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 109–160, pls. 3–5.— BATHER, F. A. The Species of Botryocrinus. *Ottawa Nat.*, vol. 20, pp. 93–104.— BEAN, T. H. A Catalogue of the Fishes of Bermuda, with Notes on a Collection made in 1905 for the Field Museum. *Field Columbian Mus.*, zoöl. ser., vol. 7, no. 2, pp. 21–89.— BLATCHLEY, W. S. The Petroleum Industry of Southeastern Illinois. *Ill. State Geol. Surv.*, bull. 2, 109 pp., 6 pls.— BOUVIER, E. L. Sur les Gennadas ou Pénéides bathypélagiques. *Bull. Mus. Océanogr. de Monaco*, no. 80, 13 pp.— BOUVIER, E. L. Observations sur les Pénéides du genre Haliporus Sp. Bate. *Bull. Mus. Océanogr. de Monaco*, no. 81, 11 pp.— BOWNOCKER, J. A. Salt Deposits and the Salt Industry in Ohio. *Geol. Surv. Ohio*, ser. 4, bull. 8, xv + 42 pp., 6 figs.— CARY, M. On the Diurnal Lepidoptera of the Athabaska and Mackenzie Region, British America.

Proc. U. S. Nat. Mus., vol. 31, pp. 425–457.— COBB, J. N. The Commercial Fisheries of Alaska in 1905. *U. S. Bureau Fisheries*, doc. 603, 46 pp.— COBB, N. A. Methods of Using the Microscope, Camera-Lucida and Solar Projector for Purposes of Examination and the Production of Illustrations. *1st Ann. Rept. Div. Path. Phys., Exp. Sta. Hawaiian Sugar Planters' Assn.*, 29 pp.— COMÈRE, J. Observations sur la périodicité du développement de la flore algologique dans la région toulousame. *Bull. Soc. Bot. France*, ser. 4, vol. 6, pp. 390–407.— DELLINGER, O. P. Locomotion of Amœbæ and Allied Forms. *Journ. Exp. Zoöl.*, vol. 3, pp. 337–358, pls. 1–2.— EVANS, A. W. Notes on Japanese Hepaticæ. *Proc. Washington Acad. Sci.*, vol. 8, pp. 141–166, pls. 6–8.— EVERMANN, B. W., AND SEALE, A. Fishes Collected in the Philippine Islands by Maj. Edgar A. Mearns, Surgeon, U. S. Army. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 505–512.— FAIRMAN, C. E. New or Rare Pyrenomyceteæ from Western New York. *Proc. Rochester Acad. Sci.*, vol. 4, pp. 215–224, pls. 20–22.— FARRINGTON, O. C. Zoisite from Lower California. *Field Columbian Mus.*, geol. ser., vol. 3, no. 4, pp. 55–57, pl. 28.— FAWCETT, H. S. Variation in Ray Flowers of *Anthemis cotula* and Other Composites. *Proc. Iowa Acad. Sci.*, 1905, pp. 55–59, pls. 12–20.— FISHER, W. K. New Starfishes from the Pacific Coast of North America. *Proc. Washington Acad. Sci.*, vol. 8, pp. 111–139.— FELT, E. P. The Gipsy and Brown Tail Moths. *N. Y. State Mus.*, bull. 103, 42 pp., 10 pls.— FELT, E. P. Twenty-first Report of the State Entomologist on Injurious and Other Insects of the State of New York. *N. Y. State Mus.*, bull. 104, 186 pp., 10 pls.— FERNALD, H. T. The Digger Wasps of North America and the West Indies belonging to the Subfamily Chlorioninæ. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 291–423, pls. 6–10.— GARCIA, F. European Grapes. *N. Mex. Coll. Agric. and Mech. Arts, Agric. Exp. Sta.*, bull. 58, 32 pp.— GARDNER, N. L. Cytological Studies in Cyanophyceæ. *Univ. of Calif. Publ.*, bot., vol. 2, pp. 237–296, pls. 21–26.— GILMORE, C. W. Notes on a Newly Mounted Skeleton of Merycoidodon, a Fossil Mammal. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 513–514, pl. 12.— HERRERA, A. L. Invasion de gusanos en los estados del centro de la Republica. *Com. Parasitol. Agric.*, circ. 45, 14 pp.— HERRERA, A. L. Destruccion de los mosquitos en las habitaciones con el polvo de crisantema. *Com. Parasitol. Agric.*, circ. 48, 5 pp.— HRDLICKA, A. Anatomical Observations on a Collection of Orang Skulls from Western Borneo; with a Bibliography. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 539–568.— INDA, J. R. Una plaga de insectos llamados "frailecillos" en el valle de Mexico. *Com. Parasitol. Agric.*, circ. 46, 8 pp. — INDA, J. R. El tabaco como insecticida. *Com. Parasitol. Agric.*, circ. 44, 5 pp.— JAQUET, M. Anomalie de la nageoire anale chez des *Sebastes dactyloptera*. *Bull. Mus. Océanogr.* de *Monaco*, no. 79, 6 pp , 1 pl.— JORDAN, D. S. AND SNYDER, J. O. A Review of the Pœciliidæ or Killifishes of Japan. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 287–290.— JORDAN, D. S., AND STARKS, E. C. A Review of the Flounders and Soles of Japan. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 161–246.— JORDAN, D. S., AND STARKS, E. C. Notes on a Collection of Fishes from Port Arthur, Manchuria, Obtained by James Francis Abbott. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 516–526.— JOUBIN, L. Description des némertiens bathypélagiques capturés au cours des dernières campagnes du Prince de Monaco (1890–1905). *Bull. Mus. Océanogr. de Monaco*, no. 78, 25 pp.— KARPINSKY, A. Die Trochilisken. *Mém. Comité Géol. St.*

Pétersb., n. s., livr. 27, viii + 166 pp., 3 pls.— KNIGHT, H. G., HEPNER, F. E., AND NELSON, A. Wyoming Forage Plants and their Chemical Composition — Studies No. 2. *Wyo. Exp. Sta.*, bull. 70, 75 pp., 31 figs.— LYON, M. W., JR. Notes on the Slow Lemurs. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 527–538, pl. 13.— LYON, M. W., JR. Description of a New Species of Great Ant-eater from Central America. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 569–571, pl. 14.— MACIAS, C. La destruccion de las ratas y los ratones del campo. *Com. de Parasitol. Agric.*, circ. 41, 25 pp.— MANGIN, M. L. Cours d'océanographie fondé à Paris par S. A. S. le Prince Albert de Monaco. (Deuxième année.) Distribution des algues: algues fixées, algues du plankton. *Bull. Mus. Océanogr. de Monaco*, no. 82, 32 pp., 3 pls.— MEEK, S. E. Description of Three New Species of Fishes from Middle America. *Field Columbian Mus., zoöl. ser.*, vol. 7, no. 3, pp. 93 95.— MILLER, G. S., JR. The Mammals collected by Dr. W. L. Abbott in the Rhio-Linga Archipelago. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 247–286, map.— MOORE, J. P. Hirudinea and Oligochæta collected in the Great Lakes Region. *Bull. U. S. Bur. Fisheries*, vol. 25, pp. 153–171, pl. 32.— NICHOLS, H. W. New Forms of Concretions. *Field Columbian Mus.*, geol. ser., vol. 3, no. 3, pp. 25–54, pls. 19–27.— NICOLAS, F. J. Catalogue of Publications of the Geological Survey of Canada. *Geol. Surv. Canada*, publ. no. 956, 129 pp.— ORTON, E., JR., AND PEPPEL, S. V. The Limestone Resources and the Lime Industry in Ohio. *Geol. Surv. Ohio*, ser. 4, bull. 4, xv + 361 pp., 53 figs.— PEPPEL, S. V. The Manufacture of Artificial Sand Stone or Sand-lime Brick. *Geol. Surv. Ohio*, ser. 4, bull. 5, 79 pp., 8 figs.— RAMALEY, F. Plants of the Florissant Region in Colorado. *Univ. of Colorado Studies*, vol. 3, pp. 177–185, 1 pl.— RAMALEY, F. The Seed and Seedling of the Mountain Globe-flower. *Univ. of Colorado Studies*, vol. 3, pp. 93–95, 1 pl.— SARLE, C. J. Arthropycus and Dædalus of Burrow Origin. Preliminary Note on the Nature of Taonurus. *Proc. Rochester Acad. Sci.*, vol. 4, pp. 203–214.— SCHAEFFER, C. On New and Known Genera and Species of the Family Chrysomelidæ. *Sci. Bull. Mus. Brooklyn Inst. Arts and Sci.*, vol. 1, no. 9, pp. 221–253.— SLOCOM, A. W. A List of Devonian Fossils Collected in Western New York, with Notes on their Stratigraphic Distribution. *Field Columbian Mus.*, geol. ser., vol. 2, no. 8, pp. 257–265, pls. 79–80.— SMITH, H. M., AND POPE, T. E. B. List of Fishes Collected in Japan in 1903, with Descriptions of New Genera and Species. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 459–499.— SPRINGER, FRANK. Discovery of the Disk of Onychocrinus and further Remarks on the Crinoidea Flexibilia. *Journ. of Geol.*, vol. 14, pp. 467–523, pls. 4–7.— SPRINGER, F., AND SLOCOM, A. W. Hypsocrinus, a New Genus of Crinoids from the Devonian. *Field Columbian Mus.*, geol. ser., vol. 2, no. 9, pp. 267–271, pl. 81.— STEBBING, T. R. R. A New Costa Rican Amphipod. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 501–504, pl. 11.— TASSIN, W. Note on an Occurrence of Graphitic Iron in a Meteorite. *Proc. U. S. Nat. Mus.*, vol. 31, pp. 573–574.— U. S. BUREAU OF FISHERIES. The Propagation and Distribution of Food Fishes in 1905. *Bureau of Fisheries*, doc. 602, 64 pp.— VERNON, J. J., LOVETT, A. E., AND SCOTT, J. M. The Duty of Well Water and the Cost and Profit on Irrigated Crops in the Rio Grande Valley. *N. Mex. Coll. Agric. and Mech. Arts, Agric. Exp. Sta.*, bull. 56, 52 pp.— VOLADORA, A. El chapulin, chocho ó langosta. *Com. Parasitol. Agric.*, circ. 47, 7 pp.— WARD, H. A. Three New Chilian

Meteorites. *Proc. Rochester Acad. Sci.*, vol. 4, pp. 225–231, pls. 23–25.— WELLER, S. The Geological Map of Illinois. *Ill. Geol. Surv.*, bull. 1, 26 pp., map.— WHEELER, H. J., AND HARTWELL, B. L. Commercial Fertilizers. *R. I. Agric. Exp. Sta.*, bull. 115, 114 pp.— WHEELER, H. J., HARTWELL, B. L., WESSELS, P. H., AND GRAY, J. P. Commercial Feeding-stuffs. *R. I. Agric. Exp. Sta.*, bull. 112, pp. 77–96.— WHITMAN, C. O. The Problem of the Origin of Species. *Congr. Arts and Sci., Universal Exposition, St. Louis*, 1904, vol. 5, 18 pp.

CONDOR, vol. 8, no. 5.— ECONOMIC GEOLOGY, vol. 1, nos. 6, 7.— ELTKA, vol. 7, no. 45.— INDIAN SCHOOL JOURNAL, vol. 6, no. 10.— JOURNAL OF GEOGRAPHY, vol. 5, no. 7.— JOURNAL OF GEOLOGY, vol. 14, no. 6.— KENTUCKY AGRICULTURAL EXPERIMENT STATION. Report on the Enforcement of the Pure Food Law. 197 pp.— LE MOIS SCIENTIFIQUE, vol. 8, no. 10.— MISSOURI BOTANICAL GARDEN. Seventeenth Annual Report, 1906, 181 pp., pls.— MUSEU GŒLDI. Boletim, vol. 4, no. 4.— NATURÆ NOVITATES, vol. 28, nos. 12–15.— NATURE-STUDY REVIEW, vol. 2, no. 6.— LA NUOVA NOTARISIA, ser. 17, Oct., 1906.— ROCHESTER ACADEMY OF SCIENCE. Proceedings, pp. 231–344.— ST. LOUIS MEDICAL REVIEW, vol. 54, nos. 9, 10, 12.— UNIVERSITY OF COLORADO STUDIES, vol. 3, no. 4.

(No. 480 was issued December 19, 1906)

To Zoologists and Museums

W. F. H. ROSENBERG

IMPORTER OF EXOTIC ZOOLOGICAL SPECIMENS

57 HAVERSTOCK HILL, LONDON, N. W., ENGLAND

Holds the largest stock in the world of specimens in all branches of Zoology.

Just published, my new Price List of **Bird-skins**, containing over 4,300 species from all parts of the world.

Also Price Lists Nos. 3, **Mammal skins, skeletons,** and spirit specimens, (over 300 species), and 5, Reptiles, Batrachians, and Fishes (over 300 species),

Any of the above lists sent post free on application.

ARE YOU INTERESTED IN PHOTOGRAPHS OF BIRD-LIFE?

Then you should send One Dollar for a year's subscription to

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

Edited by J. GRINNELL.

"The photographic illustrations alone are worth the price of subscription."
—*The Critic.*

Contributors in the past have included—
Robert Ridgway, Dr. A. K. Fisher, Vernon Bailey, Maj. Mearns, Florence Merriam Bailey, Joseph Grinnell, W. K. Fisher, Louis A. Fuertes, E. W. Nelson, F. S. Daggett, Joseph Mailliard, and other well known ornithologists.

SUBSCRIPTION, $1.00. **SAMPLE COPY, 20 CENTS.**

H. T. CLIFTON, BUS MGR., **P. O. BOX 404, PASADENA, CALIF.**

School Science and Mathematics

A MONTHLY JOURNAL FOR SCIENCE AND MATHEMATICS TEACHERS

It is the only magazine of its kind published in the English language. It gives new ideas and methods of scientific and mathematical instructions—and acts as a clearing house for all that is advanced and good in scientific and mathematics instruction. It is the official organ of many science and mathematics teachers' associations.

EIGHT DEPARTMENTS—Botany, Chemistry, Earth Science, Mathematics, Metrology, Problems, Physics and Zoology.

"Almost a necessiry." Bruce Fink, Professor of Botany, Iowa College.
"The practical hints are valuable to teachers." H. C. Cooper, Ass't Professor of Chemistry, Syracuse University.
"I value the magazine highly. It is most excellently conducted." John S. Collins, Ass't Supt. of Schools, St. Louis, Mo.
"The Problem Department is very interesting and adds greatly to the value of the magazine." H. E. Cobb, Professor of Mathematics, Lewis Institute, Chicago.
"I do not intend to dispense with the magazine as long as it continues as helpful as it has proven to be in the past." Etta M. Bardwell, Biology Department, High School, Ottumwa, Ia.
"I feel that 'School Science' should be in every high school. I shall be glad to further the interests of the journal whenever it is possible." W. M. Cobleigh, Department of Physics, Montana State college of Agriculture.
"I wish to express my appreciation of your magazine. It is a most helpful and inspiring pastime to read the sensible, to-the-point articles it contains." W. T. Heilman, Instructor in Mathematics, Central High School, Columbus, O.
"Your paper is not in the usual class of school papers. I wish to help along the kind of work you are doing." Geo. P. Bristol, Director Summer Session, Cornell University.

$2.00 PER YEAR. 25 CENTS PER COPY.

SCHOOL SCIENCE AND MATHEMATICS

440 KENWOOD TERRACE, CHICAGO, ILL.

SCHOOL SCIENCE AND MATHEMATICS will be sent for THREE MONTHS for 50 cents to a new subscriber mentioning The American Naturalist.

Bird-Lore

A BI-MONTHLY MAGAZINE FOR BIRD-LOVERS

EDITED BY FRANK M. CHAPMAN

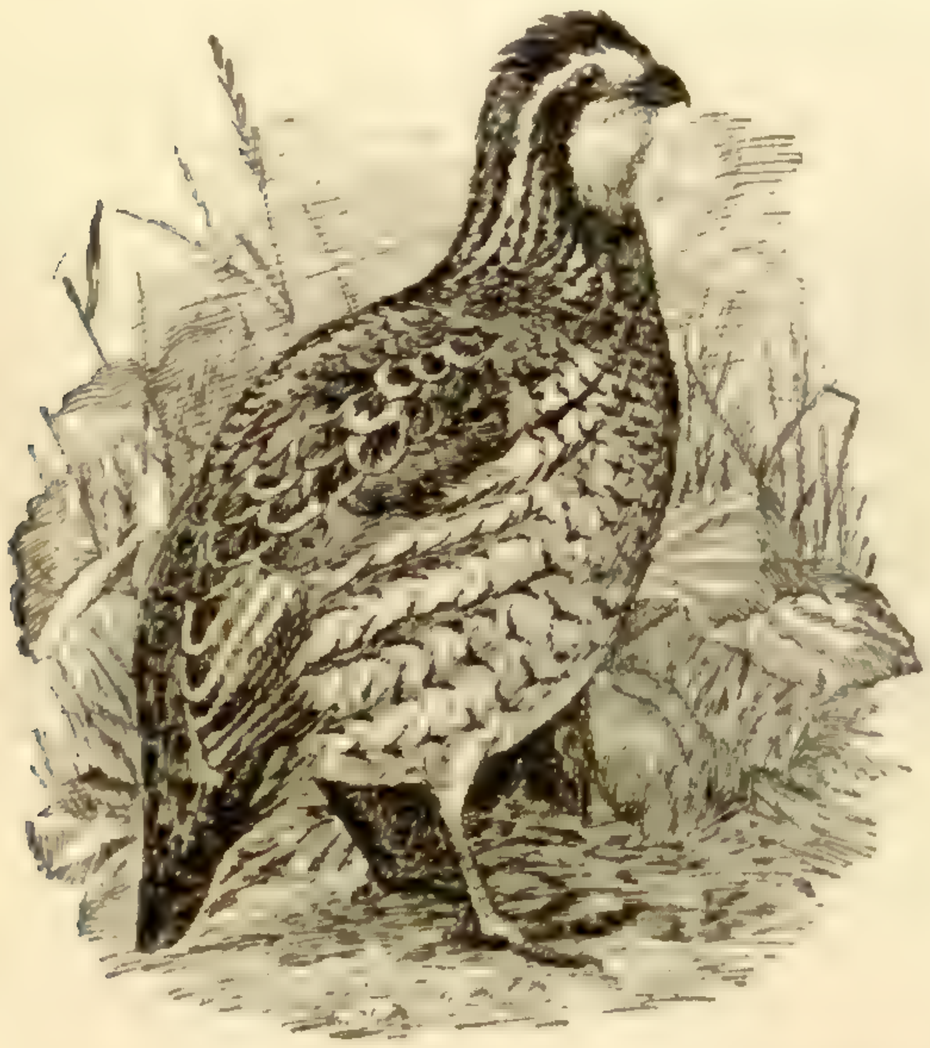
Official Organ of the Audubon Societies

Audubon Department

Edited by MABEL OSGOOD WRIGHT and WILLIAM DUTCHER

Bird-Lore's Motto: *A Bird in the Bush is Worth Two in the Hand*

If you are interested in birds, you will be interested in BIRD-LORE. Each number contains two or more colored plates, accurately figuring the male and female of several species of birds, together with numerous photographs of birds from life. The general articles and notes from field and study are interesting, stimulating and helpful; the book reviews, editorials, and Audubon Department informing, and, in short, the magazine is indispensable to every one who would keep abreast of present-day labors in the field of bird study and bird protection.



Reduced facsimile of the reproduction of Ernest Thompson Seton's drawing of the Bob-white. Presented to every subscriber to Vol. VIII, 1906, of BIRD LORE. The original, printed on heavy plate paper, suitable for framing, is nearly life size.

Each number of BIRD-LORE contains a four-page teachers' leaflet, illustrated with a colored plate. All teachers subscribing to BIRD-LORE will receive, free of charge, two extra copies of each of these leaflets, two colored plates, and six facsimile outlines for coloring, for use in their classes.

Subscription Blank

THE MACMILLAN COMPANY

66 Fifth Avenue, New York City, or Box 655, Harrisburg, Pa.

Please find enclosed One Dollar, for which mail me BIRD-LORE, Vol. VIII, 1906.

Name .....

Address .....

$1.00 a Year; 20 Cents a Copy.

READ

Economic Geology

THE

New Semi-quarterly Journal

devoted to discussions relating to the geological occurrences of materials of ECONOMIC VALUE, with particular reference to the genesis of ores.

BOARD OF EDITORS.

EDITOR.

JOHN DUER IRVING

Lehigh University, South Bethlehem, Pa.

ASSOCIATE EDITORS.

WALDEMAR LINDGREN, Washington.
JAMES F. KEMP, Columbia University, New York.
FREDERICK LESLIS RANSOME, Washington.
REINRICH RIES, Cornell University, Ithaca.
MARIUS R. CAMPBELL, Washington.
CHAS. K. LEITH, University of Wisconsin, Madison, Wis.
F. D. ADAMS, McGill University, Montreal, Quebec.

TERMS.

$3.00 per year to subscribers in the United States, Canada, Mexico, etc.

$3.75 per year to subscribers in other countries.

ECONOMIC GEOLOGY PUBLISHING COMPANY,
W. S. Bayley, *Business Manager*,
South Bethlehem, Pa.

Dear Sir:

Please send the Economic Geology to the address below for a year from.....190 . Enclosed you will find $\begin{matrix}\$3.00\\\$3.75\end{matrix}$ in payment of same.

NAME.....

ADDRESS .....

DATE..... STATE .....

N. B. Post Office orders should be made payable to W. S. BAYLEY, Manager, South Bethlehem, Pa.; checks should be made payable to GEORGE OTIS SMITH, Treasurer.

BERGEN'S
ELEMENTS OF BOTANY

REVISED EDITION

By JOSEPH Y. BERGEN,
Recently Instructor in Biology in the English High School, Boston

Including Key and Flora for Northern and Central States. 12mo. Cloth. 283 + 257 pages. Illustrated. List price, $1.30; mailing price, $1.45. Without Key and Flora. List price, $1.00; mailing price, $1.10.

Issued also in three special editions with a Key and Flora for each: Pacific Coast Edition, Southern States Edition, and Rocky Mountain Edition. List price, $1.30 each; mailing price, $1.45.

BERGEN'S "Elements of Botany," Revised Edition, is designed to furnish a half-year course in the subject for students in secondary schools. It covers all the ground which ordinary classes can traverse in the time indicated, and presents only those topics which are essential to an elementary course in the science.

It differs from the earlier editions of the "Elements" mainly in the greater stress laid on the topics of ecology and cryptogamic botany, in the somewhat abbreviated directions for histological work on seed plants, and in the greatly improved quality of the illustrations. Minor changes will be found on almost every page.

THE BOOK IS CHARACTERIZED

By the natural method of presentation, introducing the pupil first, as Professor Huxley recommended, to the comparatively familiar forms and processes of plant life.

By the sparing use of technical terms, employing these only when they are indispensable for the sake of clearness or of brevity.

By the treatment of the structures and the functions of plants consecutively, not in widely separated portions of the book.

By the intimate combination of laboratory work with discussion, taking pains, however, not to tell the pupil, either in words or by means of illustrations, what he is to see before he sees it for himself.

By the accuracy of the illustrations in detail, the half tones being used *only to give general effects, never for minute organs or structures.*

By the fact that four special keys and floras have been prepared to accompany the text. This allows the student in any part of the country to obtain practice in the determination of species of phanerogams, and to get a practical idea of their relationships and classification by means of a simply written and inexpensive flora of his own region.

BOTANY NOTEBOOK

To accompany Bergen's Text-Books on Botany, and for general use in Botanical Laboratories or for Secondary Schools. Square 4to. Cloth. 144 pages. List price, 45 cents; mailing price, 60 cents.

BERGEN'S Notebook was prepared with the particular view of minimizing the amount of routine dictation for both teacher and pupil without doing any of the latter's thinking for him. Not only will it save time and trouble, but it will also lead the pupil to perform neat and accurate work.

GINN & COMPANY PUBLISHERS

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS — HERBERT S. JENNINGS — THOMAS H. MORGAN
WILLIAM E. CASTLE — FRANK R. LILLIE — GEORGE H. PARKER
EDWIN G. CONKLIN — JACQUES LOEB — CHARLES O. WHITMAN
CHARLES B. DAVENPORT — ROSS G. HARRISON, *Man. Ed.* — EDMUND B. WILSON

Volume I, containing 616 pages, 5 plates, and 478 text illustrations, and Volume II, containing 630 pages, 12 plates, and 228 text illustrations, are now complete.

CONTENTS OF VOLUME III

No. 1 — FEBRUARY, 1906

Studies on Chromosomes. III. The Sexual Differences of the Chromosome-Groups in Hemiptera, with Some Considerations of the Determination of Sex. . . . . **Edmund B. Wilson**

An Examination of the Effects of Mechanical Shocks and Vibrations Upon the Rate of Development of Fertilized Eggs . . . **David D. Whitney**

Morphology of the Parthenogenetic Development of Amphitrite. **John W. Scott**

The Development of Fundulus Heteroclitus in Solutions of Lithium Chlorid, with Appendix on its Development in Fresh Water. **Charles R. Stockard**

Partial Regeneration of the Sperm-Receptacle in Crayfish. . **E. A. Andrews**

Experimental Study of Light as a Factor in the Regeneration of Hydroids. . . . . **A. J. Goldfarb**

No. 2 — JULY, 1906

Experiments on the Behavior of Tubicolous Annelids . . . **C. W. Hargitt**

Inheritance of Dichromatism in Lina and Gastroidea . **Isabel McCracken**

The Elementary Phenomena of Embryonic Development in Chætopterus. . . . . **Frank R. Lillie**

The Regeneration of Grafted Pieces in Planarians . . . **Lilian V. Morgan**

No. 3 — SEPTEMBER, 1906

Locomotion of Amoebae and Allied Forms. . . . . **Oris P. Dellinger**

The Influence of Light and Heat on the Movement of the Chromatophore Pigment, especially in Lizards. . . . . **George H. Parker**

Light Reactions in Lower Organisms. I. Stentor Coeruleus. . **S. O. Mast**

Some Reactions of Caterpillars and Moths. . . . . **Alfred G. Mayer and Caroline G. Soule**

Modifiability in Behavior. II. Factors Determining Direction and Character of Movement in the Earthworms. . . . . **H. S. Jennings**

A Study of the Spermatogenesis of Coptocycla Aurichalcea and Coptocycla Guttata, with Especial Reference to the Problem of Sex Determination. . . . . **W. N. Nowlin**

No. 4 — IN PRESS

The Influence of Gases and Temperature on the Cardiac and Respiratory Movements of the Grasshopper. . . . . **E. A. Walling**

The Physiology of Regeneration. . . . . **T. H. Morgan**

Torsion and Other Transitional Phenomena in the Regeneration of the Cheliped of the Lobster (Homarus Americanus). . . . . **Victor E. Emmel**

The Relation Between Functional Regulation and Form Regulation. **C. M. Child**

Studies on the Development of the Starfish Egg. . . . . **D. H. Tennent and M. J. Hogue**

Hydranth Formation and Polarity in Tubularia. . . . . **T. H. Morgan**

PRICE OF SUBSCRIPTION PER VOLUME — *Payable in Advance*

To subscribers in the United States, Canada, and Mexico,	$5.00
To subscribers in other Countries, ...	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount.

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to THE JOURNAL OF EXPERIMENTAL ZOÖLOGY. Address all communications to

THE JOURNAL OF EXPERIMENTAL ZOOLOGY,
N. E. COR. WOLFE AND MONUMENT STREETS,
BALTIMORE, MD., U. S. A

PLEASE MENTION THIS JOURNAL.

FROM $175 TO $6

If you were to subscribe for the English quarterlies, magazines, reviews, and literary, political, and scientific journals from which THE LIVING AGE takes its materials, they would cost more than $175. You would also waste a good deal of time in sifting out the important from the trivial, and determining what was really worth your reading.

THE LIVING AGE practises this art of skipping for you, and gives you, for $6, in a single weekly magazine, light and easy to hold, the best essays, the best fiction, the best poetry, and all the most timely and important articles from this long list of periodicals, reprinted without abridgment.

Six Dollars is not a large sum to pay for 3,300 pages of the best contemporary reading, covering all subjects of human interest, and embodying the freshest thought in literature, art, international affairs, and current discussion.

THE LIVING AGE presents each year twice as much material as is contained in one of the four-dollar monthly magazines. As it has the whole field of English periodical literature to select from, it is able to present a wider range of subjects, treated by a more brilliant list of writers, than any single magazine, English or American.

But you can buy a magazine for less money? Certainly. There are more magazines than one can easily count which may be had for one dollar a year each.

But there are magazines and magazines. THE LIVING AGE presupposes intelligence and an alert interest in what is going on. To people of that sort it has ministered successfully for more than sixty years. It holds its field alone, and it was never more nearly indispensable than now.

Subscribers for 1907 will receive free the remaining numbers for 1906.

THE LIVING AGE CO.

6 BEACON STREET, BOSTON

Please mention THE AMERICAN NATURALIST

VOL. XLI, NO. 482 FEBRUARY, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	An automatic Aerating device for Aquaria	DR. LOUIS MURBACH	61
II.	The Flying-Fish Problem	LIEUT.-COL. C. D. DURNFORD	65
III.	Cataloguing Museum Specimens	PROFESSOR L. B. WALTON	77
IV.	Some South American Rotifers	JAMES MURRAY	97
V.	Meristic Homologies in Vertebrates	J. S. KINGSLEY	103
VI.	On the Osteology of the Tubinares	DR. R. W. SHUFELDT	109
VII.	Notes and Literature: *General Biology*, Transmutation and Agriculture, Form Analysis; *Geology*, River Terraces at Brattleboro, Vt.; *Anthropology*, Quaternary Remains of Man in Central Europe, Pagan Races of the Malay Peninsula, Growth of Parisian Children, Anthropometric Data on the Norwegians, Population of Tripoli; *Zoölogy*, Dean's Chimæroid Fishes, Development of the Mammalian Lung, Half Hours with Fishes, Reptiles and Birds, Notes; *Botany*, The Journals		125

BOSTON, U. S. A.

GINN & COMPANY, PUBLISHERS

29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca.*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Lake Forest University*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in Anthropology, General Biology, Zoology, Botany, Paleontology, Geology and Physical Geography, and Mineralogy and Petrography. The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; and in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, critical reviews of recent literature, and a quarterly record of gifts, appointments, retirements, and deaths.

All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to THE AMERICAN NATURALIST, Cambridge, Mass.

All business communications should be sent direct to the publishers.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *February, 1907* No. 482

AN AUTOMATIC AËRATING DEVICE FOR AQUARIA

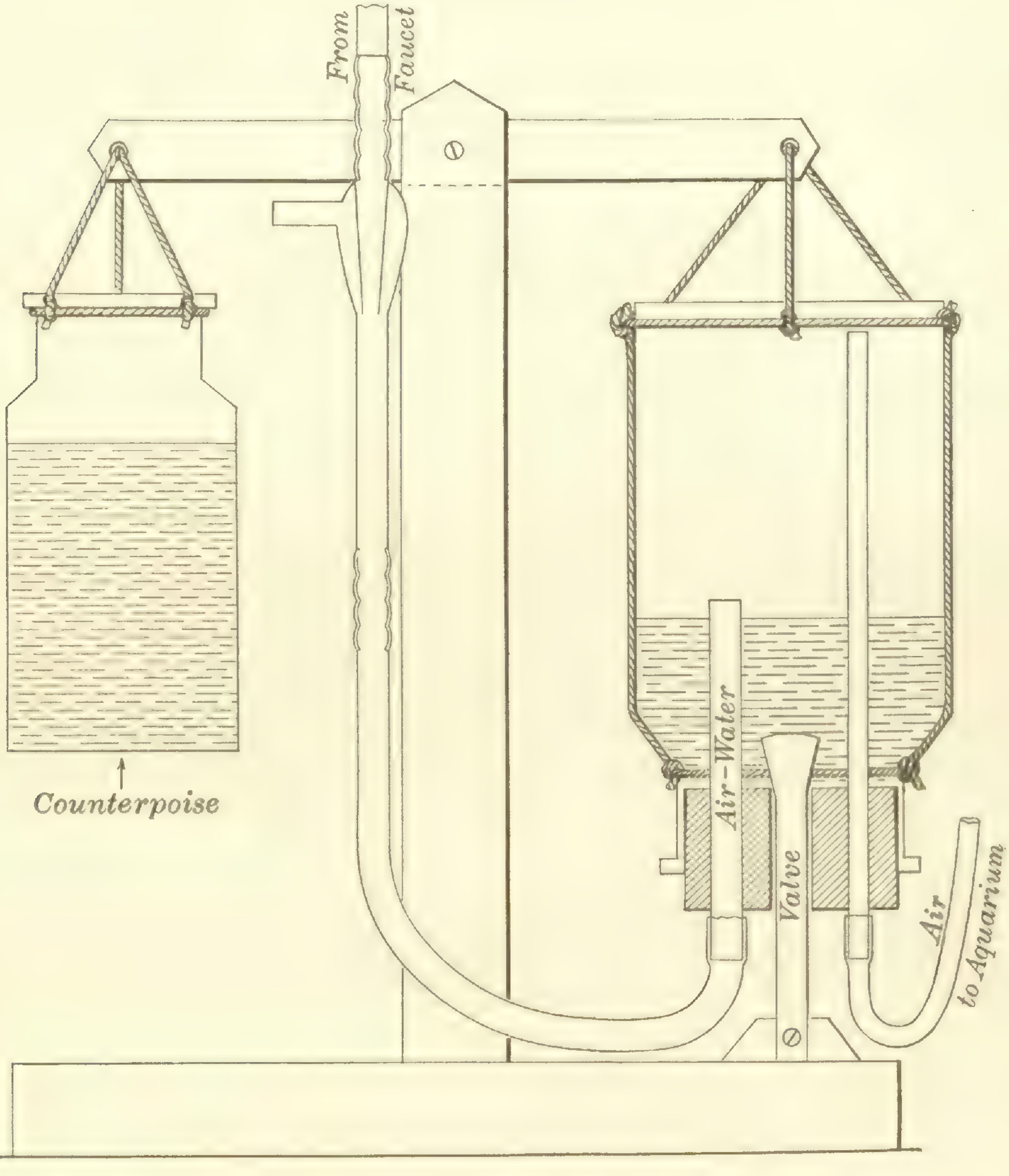
LOUIS MURBACH

THE use of the water blast as a means of aërating is well enough known to need no more than passing mention. Its cost is prohibitive for smaller schools and its use limited to laboratories where noise would not be a disturbing factor. Furthermore it may be desirable to have an aquarium under observation in different rooms. Some time ago a simple device was described (*Amer. Nat.*, vol. 38, no. 453, 1904, pp. 655–661, 2 figs.) which, however, necessitates the exchange of the water in the aquarium. This might involve the loss of organisms if the flow were continuous as from a tap, or it would necessitate lifting the water periodically.

These were some of the difficulties I encountered when about a year ago I wished to aërate some small aquaria containing sea water, in a class room where fresh water was available, but a flow of sea water could not be had. An ordinary filter or vacuum pump was fitted into a calcium-chloride jar about 45 cm. tall. The accumulating air in the jar was carried through the stopper by a small tube to the aquarium. A ball valve of paraffin held against the lower opening of the jar by a lever and weight was to regulate the outflow of water. This and similar devices tried, failed to regulate the varying pressure in the supply pipes, and was not satisfactory. If regulated for the day when more taps were in use, the pressure increased during the night, with few or no other taps on, so that the fresh water overflowed through the air tube and diluted the sea water.

The above obstacles were entirely overcome in a device that I hit upon the past summer at the Marine Biological Laboratory

Woods Hole, in attempting to aërate the sea water in which Gonionemus was kept, rather than to use the water from the pipe. Other workers have carried water daily from the end of the pier to get more favorable results than with the water from the pipes. It remains to be seen whether aëration and cooling will answer



these and other purposes. While I got very satisfactory results, yet my observations this season were not numerous enough to warrant any general claim for all-around usefulness.

A general idea of the apparatus may be gained from the figure. The things needed are a glass filter pump, two wide-mouth bottles, about 8 × 15 cm., and 6 × 12 cm., a cork stopper to fit the larger

bottle, a stand with balance beam, glass and rubber tubing. The stopper is bored with three holes, 5 mm., 8 mm., and 11 mm. in diameter. Into the smaller holes are fitted a 24 cm. long tube for the air outflow and a 15 cm. long tube for carrying the water from the filter pump. The 11 mm. hole is for a wooden rod, 15 mm. in diameter and about 15 cm. long. This is cut down tapering abruptly from 15 mm. to 8 mm. the rest of its length. The larger end of this rod serves as a valve in the 11 mm. hole in the stopper being placed vertically so that the stopper can glide freely along the rod when placed in the inverted bottle.

A few details will be desirable for those who wish to try the apparatus. After inserting the glass tubes as shown in the figure, the wooden rod is inserted through the stopper from the side that goes into the bottle. Then the small end of the rod is attached to a block. Now the larger bottle is suspended in inverted position from one end of the balance beam of the stand, the stopper is inserted and the smaller bottle nearly filled with water is hung on the opposite end of the beam for counter-poise. The block carrying the wooden rod is moved about on the base of the stand until the stopper moves easily up and down the rod, and is then fastened in this position with a wood screw. The length of the cord supporting the inverted bottle should be so adjusted that the beam on this side is a little higher than on the opposite side when the stopper is drawn up against the head of the wooden rod as far as it will easily go. If the head of the rod fits the hole in the stopper accurately no water will escape when it is turned on until the weight of water in the inverted bottle exceeds that of the counterpoise. Now the weight of the counterpoise may be adjusted so that it will keep the larger bottle about $\frac{1}{3}$ full of water, thus preventing the escape of air except through the proper outlet. The water and air should not discharge alternately and if this does take place, a longitudinal groove may be cut into one side of the head in the stopper until enough water escapes to balance the inflow when the water pressure is at its lowest. From this on it will work automatically. Several other forms of valves may be used but I have found the one described the simplest.

If it is desired, more than one aquarium may be aërated with the same apparatus by dividing the air with T-tubes and using

pinch cocks until the desired flow is obtained in each, necessitating, however, more attention than the simpler form. The main features of this apparatus are: its automaticity, its noiseless action making it suitable for the class room or laboratory table, its simplicity and inexpensiveness.

Detroit, Mich.

THE FLYING-FISH PROBLEM[1]

LIEUT.-COLONEL C. D. DURNFORD

In a paper published in the *Annals and Magazine of Natural History* for January, 1906, the impossibility, from a mechanical point of view, of a flying-fish accomplishing sailing flight was shown. The argument was based upon the fact that as a flying animal the flying-fish is equipped with wings of a fractional sailing value compared with those of a sailing bird. Also that if the wings were many times larger, so as to bring the fish on an equality with the bird in this respect, it could only sail with the bird's limitations as regards direction of the wind, and with the bird's frequent assistance from rowing flight. Also that if the figures (which can be easily verified or, if wrong, refuted) are correctly given in the article, the accepted aeroplane flight is miraculous, unless a new law of Nature be discovered.

It is, then, perhaps advisable, if the present curious condition of the question is to be understood, to examine how it has come about.

The flying-fish problem is a very odd one in many ways, of which the most striking is the unexplained power therein of the negative to quench the positive. Throughout we find the aeroplanist's "I cannot see the wing-movement" smothering a fairly equal bulk of "I can, and have, and do see it."

Let us create a parallel instance, for a real parallel does not perhaps exist:— Many people can see bullets in their flight. Many others with equally good, or even better, sight cannot pick up the flying bullets. Now if those who fail to see them said, and if all books and papers on shooting supported them in so saying,

[1] This article was intended to appear simultaneously in the *American Naturalist* and in the Annals and Magazine of Natural History but delays in the mail prevented. The subject however is of such interest that its later publication here may be pardoned.—EDITOR.

"I cannot see the bullets, therefore you, and all those who do see them, do not see them," we should have a parallel to the current odd mode of conducting the flying-fish problem.

It is in consequence of this supremacy of the negative that the flying-fish problem has earned for itself the name of "eternal," for as soon as one new witness can see the flight, either another new one fails to do so, or a reference is made to some observer who has formerly so failed; and this is equally satisfactory, for, in the problem, even an old "I did not" is better than a new "I do."

It might naturally be supposed that there must be an overwhelming backing of probability, both mechanical and natural, to the negative evidence in order to justify such dogged denial to the affirmative of its common value. So far, however, from this being the case, it is a second odd fact that but one seemingly practical effort at proof has been made, and with this one exception aeroplane flight rests wholly upon the flat negative.

Let us examine this solitary attempt at proof.

I requote from an article, which may be taken as typical of the system, in the 'Annual Report of the Smithsonian Institution,' 1904, p. 498, by Dr. Theodore Gill, an emphatic aeroplanist:— "Möbius (1878, 1885) contended that 'Flying-fish *are incapable of flying* [the italics are his], for the simple reason that the muscles of the pectoral fins are not large enough to bear the weight of their body aloft in the air.'" If undisputed that is, without doubt, a most powerful argument — decisive, in fact. But mark! almost immediately Prof. Whitman, a high authority, denies its accuracy. In the same article we find that this statement is "vigorously objected to by C. O. Whitman (1880), who urged, 'Admitting that in form, size, length, and structure the pectoral fins of *Exocœtus* are less well adapted to flight than the wings of most birds, there is still ample room to believe, on anatomical and physiological grounds alone, that they are capable of executing true flight.'" This is a plain statement moderately worded by a distinguished physiologist and naturalist, and it is interesting to note that it is answered, as though by convincing argument, by the old irritating *impasse* — the reference to views of distinguished naturalists as to whether flying-fish fly or do not fly, and entirely ignoring the new muscle aspect opened by Whitman.

Among the distinguished naturalists thus referred to in support of Möbius's theory, Prof. Moseley, as being of the 'Challenger' Expedition, and Mr. Boulenger are prominently mentioned. But Moseley, who cannot see the *Exocœtus* flapping, can see the Dactylopterids doing so (p. 512): the possibility of which act is denied by Möbius from personal observation as strongly as in the case of *Exocœtus!* Whilst Boulenger merely quoted the verdict of others, he himself retained, then as now, as he informs me, an open mind upon the question.

It is surprising how largely this "general verdict" is influenced by the researches of Möbius, the very Professor whose solitary so-called proof is questioned by Whitman; so we will examine more closely what he says about the muscles. The quotation is continued from "'aloft in the air,'" above.

"'The pectoral muscles of birds depressing their wings weigh, on an average, one sixth of the total weight of the body, the pectoral muscles of bats one thirteenth, the muscles of the pectoral fins of flying-fish only one thirty-second.'"

If this proves anything — which to the purpose it does not — it may prove that, as flying-fish have somewhat less than half the comparative muscle of bats, and (according to aeroplanists) cannot, for this reason, fly, therefore bats, which have somewhat less than half the comparative muscle of birds, cannot fly.

Or, the other way about: — Birds can fly. Bats, having rather less than half the comparative muscle of birds, can fly; therefore flying-fish having rather less than half the comparative muscle of bats, may fly.

Those are reasonable deductions, but "therefore flying-fish cannot fly" is an unreasonable one.

It is quite clearly a question of degree, and the true deduction is that bats, if they can fly, cannot be expected to fly like birds, and flying-fish, if they can fly, cannot be expected to fly like either bats or birds; and, I may add, no one thinks or claims that they do so fly.

But an even greater claim is made by aeroplanists. It is recognized that there are two kinds of bird-flight, "sailing" and "rowing," the sailing being greatly the superior form. Sailers can always row, but rowers cannot properly sail on account of their low wing

to weight ratio.[1] Now flying-fish have a ratio of the lowest class in comparison with birds (see 'Annals,' Jan. 1906, p. 162); yet they are credited by aeroplanists with sailing of a higher form than that of the best-equipped sailing birds — sailing, without even occasional rowing assistance, at a slow speed, regardless of the direction of the wind ! Such a feat — one utterly impossible for an albatross,[2] an eagle, a vulture, kings of flight — is given to this last poor dabbler in the art upon persistently contradicted negative evidence, two impossible parallels, and the one discredited proof.

I have endeavored in the foregoing to show how observers have been weighted and clogged by the unique system of handling an admittedly difficult question — how a very able man, Prof. Möbius, years ago undertook a research which required a very special knack of eyesight in the observer. Probably the majority of men are without this knack, and do not know it. Firmly believing what I have endeavored to show must have been the false view presented to his retina, to be a true view, he wrote, with the cleverness that belonged to him and the dogmatism of the believer, the text of the faith which has guided and misguided scientists for over a quarter of a century. His reputation was, and is, deservedly great — so great that his word was practically law, and it came about that if other scientists possessed the knack of sight and differed from him so much the worse for them; they must be either ignored, or explained away, any or no explanation being sufficient for such a proper purpose. This is not a hard judgment. Anyone, who is free from the superstition, on reading an ordinary aeroplane article will recognize its justice.

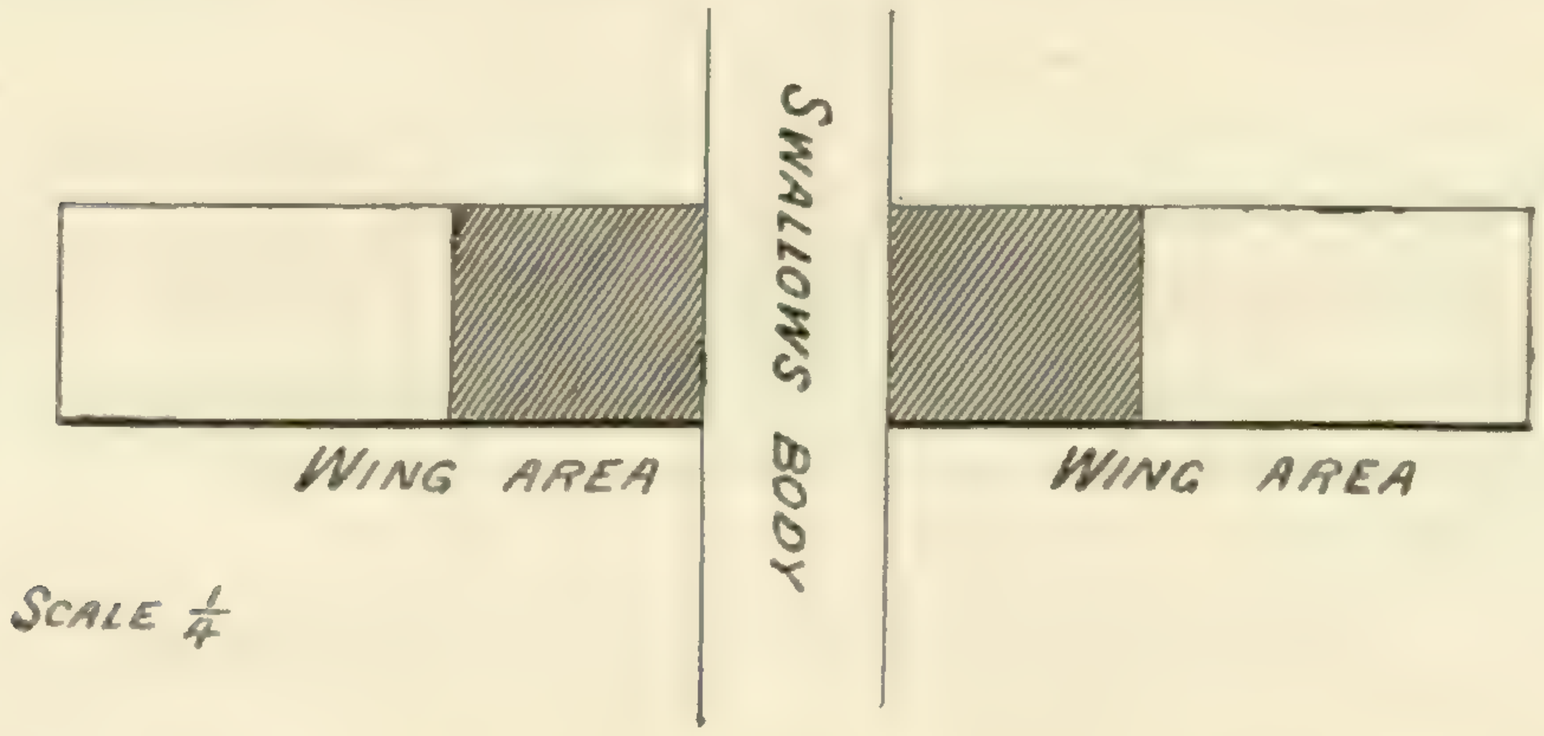
[1] Harting's formula $\frac{\sqrt{\text{wing-surface in sq. cm.}}}{\sqrt[3]{\text{weight in grammes.}}}$, which governs this ratio in birds, is impugned by R. von Lendenfeld in the volume that we have been quoting from (Ann. Rep. Smith. Inst. 1904, p. 129). The figures of his example in proof will not, however, bear examination. Correctly calculated they strongly support Harting $\left(\frac{\sqrt[2]{336}}{\sqrt[3]{320}} = 2{\cdot}68\right.$, and *not* 4·03 as given by Von Lendenfeld as the ratio of the partridge$\left.\right)$.

[2] Some notes by Prof. Moseley ("Notes by a Naturalist on the 'Challenger,'" p. 571, 1874) upon the small amount of true soaring performed even by the albatross are instructive. Our eyesight misleads us again in this matter.

Take a quite typical example of the common aeroplane blind-fold acceptance from writer to writer of palpable impossibilities as guiding facts. In the article that we have been quoting from we may note the following (p. 500): "The best estimate has been that an ordinary flight may extend from 30 to 50 yards in less than twenty seconds." In order to get working figures we may call "30 to 50 yards" 40 yards, and "less than twenty seconds" 15 seconds. This gives a rate of $5\frac{1}{2}$ miles an hour!

Note this, you who watch the fish fleeing before a 14–knot steamer.

Such statements are the habit of the problem. Just in the same way is it its recognized habit to quote, unquestioned, as "sailing" parallels to the heavy small-winged fish, the $\frac{3}{4}$-oz. large-winged swallow, and the parachute whose work is falling only; or, again, to faithfully reproduce over and over again pictures of impossible air-currents performing feats also impossible; or to continue to ascribe the frantic efforts at flight of a fish fallen on deck to natural spasms, although it is not credited with active use



of its wings either in air or sea; and so on. It is the way of the problem, and no one is to blame.

Perhaps the odd unsuitability of the swallow comparison may be brought more fully home by a sketch.

The ratio (Harting's formula) of a swallow (house-martin) is 4.2, and its wing-area 120 sq. cm. The flying-fish ratio is 2.6. If we reduce the swallow to a 2.6 ratio, its wing-area becomes about 47 sq. cm.

This reduction to flying-fish ratio is shown by the shaded parts of the sketch.

Could anyone contend that a swallow could sail even in its present poor and much-assisted way (for it is far from being a first-class sailer) if the unshaded parts of the wing-areas were removed?

Opinion is, however, undoubtedly changing. Many of the old shibboleths are fast becoming discredited. The great distances that the fish, under favoring conditions, fly clear of the water [1] — the fact that they fly in calms as in winds — that they come on board ships from lee and weather sides indifferently — that they can and do turn in air [2] — that they often lose and often gain speed, both from simple causes, on meeting a wave or on tail-dipping — that they can and do at times gain speed whilst still in air — that they make for lights deliberately — that they rise and fall of set purpose while in the air: all these and much more that has been under the ban are being witnessed and certified to so incessantly that soon only the high-priests of aeroplane will be left contradicting them.

F. G. Aflalo ('Natural Hist. of Australia,' Macmillan & Co., 1896) writes: "I have watched these beautiful creatures by the hour and in all weathers, ... but after having closely watched thousands of them through strong glasses, I cannot give as emphatic

[1] It is difficult to judge distance at sea. The tendency is to underestimate it. Many observers testify to having seen flights of more than a quarter of a mile. Frank Bullen, in his article upon flying-fish in 'Creatures of the Sea,' insists that he has seen flights of over a mile. He has had exceptional opportunities for observing them, and I see no reason for thinking that he is mistaken.

[2] With reference to their turning powers. I mentioned in the former paper a fish which I had seen to turn back in air. I then restricted myself to the bare facts required for the argument. It had interested me, however, much at the time, not only because it was, to me, a rare occurrence, but also because the controlling cause of the fish's remaining and turning in air was quite evident. The sea was rather calm and the ship was throwing out, with each gentle roll and dip, those broad hissing tables of white foam which spread away for many feet from her sides, and die in a mass of struggling bubbles, to reappear as the white broad rushing table of the next dip. The fish had risen independently of the ship, and was flying towards us at full speed, when a sudden slow down marked its perception of the advancing monster. There was no time, however, for it to decide whether water or air was the less perilous before it was over an unusually broad table of boiling foam. The hidden and fearful possibilities of this evidently decided it, and then ensued its slow but successful struggle to turn and get clear of the concealed horrors. This it did with what must have been a terrific effort, but it got quite round and well away out into the blue water before it dived.

an opinion as I should like on the oft-discussed question of whether the wings vibrate like those of birds.... If the pectoral fins are so constituted as to be capable of vibration, then I would say as the result of my own observations that to some slight extent they do flap, not like those of birds, perhaps, certainly not like those of the bat."

I have quoted the above as it expresses markedly two common difficulties: (1) the real difficulty in discerning the movements; (2) the pre-acquired idea that the wings are not fitted for flapping, an idea which naturally greatly increases difficulty (1). Had Mr. Aflalo been certain of the two facts that the wings were fitted for flapping and that "sailing" was for the fish ordinarily impossible, it cannot be doubted that his views would have been stronger and expressed very differently.

Among quite recent papers upon this question, two should be especially noted. Lionel E. Adams, B. A., writes in the 'Zoologist' (April 4th, 1906) an article interesting throughout. I quote from p. 146: "..... I was often able to see them against the sky.... I could see quite distinctly that their tails were vibrating very rapidly from side to side during the whole flight, and that the wings would vibrate with an intensely rapid shivering motion for a second, then remain outspread motionless for one or two seconds, and then vibrate again. This vibration of the wings is not up and down as in the case when birds fly, but in an almost horizontal direction."

That is a quite possible explanation of the mode of flight, provided that a sufficient speed be acquired in the intermediate flappings, but this the known speed of the fish shows to be not commonly the case.

Again, on p. 148: "I am perfectly well aware that a casual glance at flying-fish from the lofty deck of a liner gives the impression that they soar like birds with motionless wings, but watch them at close quarters from the deck of a low-waisted tramp and the vibratory motion of the tail and fins will be quite plain."

Interesting as is Mr. Adams's paper, I cannot but think that he is partly mistaken in his views, and that the wing-vibration which he discerned was really less rapid than the movement in the period following which he believed to be one of stillness, just as the line-passengers mistook his vibrations for stillness. I do not say that

the fish could never arrive at a speed by which a very short aeroplane flight could be attained even with their low ratio; but I do say that such is not their common speed, and that in any case their disregard of wind-direction disproves such flight.

Therefore another way must be looked for, and we are driven back, perforce, to continuous wing-action, the manner of which may be here examined as carefully as our information allows.

Premising that the flight varies greatly on different days and under different conditions, the following is probably a fair description of their methods in an ordinary flight:—

1. The tail-impelled, visibly (to many) wing-assisted jump from the water to a height where the wings can work freely.

2. The flight continued by an intensely rapid and labored wing-movement — one easily mistaken for stillness, and usually seen, if at all, as blur.

3. Short periods of slowing down of wing-speed, during which the wing-movement becomes again visible. (These are the "vibration" periods, representing to aeroplanists loose wing-trailing, or dragging like a flapping flag—an impossibility; and, to Mr. Adams, periods of wing-assistance — with limitations a possibility.) These periods often precede a special spurt such as is required to lift the fish over an oncoming wave.

4. Either sudden cessation of wing-movement and consequent immediate drop into the sea or a short slow down into visibility (No. 3) previous to such drop.

It is to be noted that this vibration so often seen before the fish enters the water is one of the many pointers to continuous wing-movement, for such a time is a proper one for slowing down, but an absurd one for renewal of wing-effort.

To return to Mr. Adams's paper. He notes, as have others, the vibration of the wings as being in "an almost horizontal direction." This horizontal movement, if it exists, as is probable, may afford, as I hope to show, a looked for key to the fish's action.

According to Pettigrew, it is a necessity of flight, where wing-beats are in a more or less vertical direction, that the up-beat should meet with little and the down-beat with much resistance from the air. This is arranged for in the case of bats, birds, and certain insects by means of special muscles and ligaments which automat-

ically flex the wing for or during the up-stroke, and extend it for or during the down. (Pettigrew, 'Animal Locomotion,' Int. Science Series, vol. vii. pp. 122, 182, 194, &c.: 1891.)

Marey ('Animal Mechanism,' p. 263 &c.: Int. Science Series, 1893) equally recognizes the necessity for a diminished wing-area in the up-stroke, but believes it to be obtained in birds through the natural elasticity of the feathers, which enables them to return to their ordinary position when the resistance of the air in the down-stroke ceases to raise them.

The flying-fish's wing, as is known, is formed on quite a different principle from that of a bird or bat. It opens and closes somewhat like a fan. A partial automatic closing of this fan at the foot of the downward stroke in flight and opening at the top of the rising stroke would both give the appearance of horizontal vibration when seen either from above or below, and would turn a somewhat difficult question of the mechanics of the flight into a very simple one. Indeed we have here flying action on the same general principle as that shown by Pettigrew and Marey to be necessarily provided for in the case of bats and birds, but the working details of which are different and simpler, as becomes a simpler form of wing.

Perhaps that is the explanation. There must, of course, be some explanation, and that is not only the natural deduction from the peculiar formation of the wing, but it also fits everything in.

The known (but indistinct) visibility of the larger rays of the wings at times during flight points, perhaps, to a comparative pause with wings full open before beginning the down-stroke. Such pause would give the open position, and with it the wing-tracery prominence.

The form of these fishes' wings points to this fan-action rather than to other known horizontal wing-actions of the nature of that of certain insects — the common fly, for instance (Marey, *loc. cit.* pp. 204, 206).

The second quite recent and very important observer and writer on this subject is convinced of the flight-action. He writes also from personal observation, and is as free from proper mechanical bias as from the improper follow-my-leader habit. One of his remarks, "It is by no means impossible that flying-fish may soar,

as *even* [my italics] birds do this," shows his mechanical freedom. In a paper dated Oct. 28th, 1905, Brig 'Galilee,' North Pacific Ocean, Dr. J. Hobart Egbert, Carnegie Expedition, writes ('Forest and Stream,' Jan. 27th, 1906): "'Though still denied by some observers, the power of propulsion through the air by means of its fin-wings is generally accorded the flying-fish.[1] During months at sea in the tropics the writer has almost daily watched the flying-fishes and studied their flight through the air.... The difficulties of assuring oneself that the flying-fish moves its wings during its flight through the air are well understood, and also the fact that these difficulties are generally removed when opportunity is afforded of observing the flight of certain of the larger species under favorable conditions. That flying-fishes use their wings after the manner of birds, at least upon emerging from the water, can hardly be denied, since from the fo'c's'le head of a ship plying the waters of the lower latitudes this wide bird-like motion of the fin-wings may be easily observed as the large flying-fishes break water almost under the vessel's bow. This flapping motion of the fin-wings is not, however, long maintained, but as soon as the fish is well started in the air apparently passes into a vibratory motion of the appendages so rapid as to be almost beyond human visual perception."

Quite so. That is the to-be-expected flight of an exceptionally low-ratio flyer having special added natural disabilities. Before long it will be the accepted one for flying-fish.

More about the Pectoral Muscles.

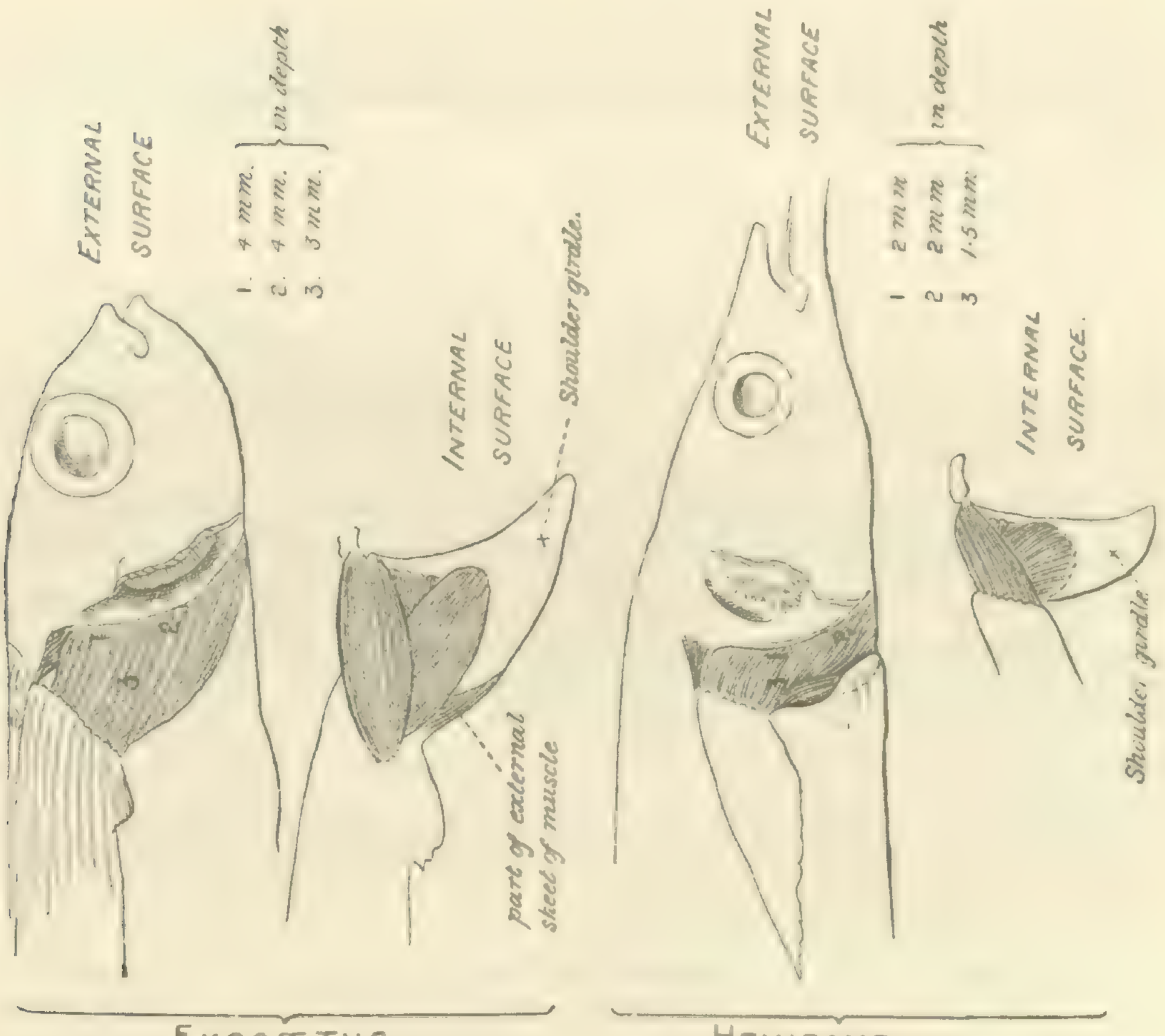
Since writing the foregoing I have received a communication from Prof. C. Stewart, F. R. S., Conservator of the Museum of the Royal College of Surgeons, who kindly gives me permission to use the results of a dissection made at the Museum for the purpose of comparing the pectoral muscles of the flying-fish with those of a nearly related non-flying fish.

I quote from the letter of Mr. Burne, who made the dissection:—

[1] A little premature, if Natural Histories and Encyclopædias are any indication of general accord.—C. D. D.

"Royal College of Surgeons of England,
Lincoln's Inn Fields,
London, W. C., 18th June, 1906.

"DEAR SIR,—.... I have made a dissection of the pectoral muscles of a flying-fish (*Exocœtus* sp.) and of a nearly related fish of much the same build, but without the enlarged pectoral fins (*Hemiramphus*). Both were specimens from our store-room, and although in pretty good condition had evidently been in spirit for a considerable time. I enclose you tracings of the drawings I



EXOCŒTUS HEMIRAMPHUS

made. The two of the external view were drawn with a camera, and the *Hemiramphus*, which was rather less in girth than the *Exocœtus*, was so much enlarged as to have the same girth about an inch behind the pectorals. I thought that body-girth sufficiently far behind the fins not to be influenced by their degree of develop-

ment was the best standard of size to take — better than length, for instance. As a matter of fact, the fish were very much the same length; the *Exocœtus* being rather the longer.

"The drawings, I think, explain themselves. The flying-fish muscles were, as you see, considerably larger, both in area and in thickness, than in *Hemiramphus*, and the same was the case with the muscles on the deep surface of the fin. In their arrangement they were much the same in both fish and the same as in other bony fishes (the cod, for instance). The numbers on the surface of the fins are the points where I took the thickness of the muscles by plunging a needle into it and measuring the depth to which the needle entered. You will notice the great length of the muscles in *Exocœtus*: a long muscle means a proportionate length of contraction.

". . . . there is a very marked difference in the size of the muscles of these two fishes. . . .

"Believe me, yours faithfully,

R. H. BURNE

(*Assistant in Museum*).

The above tracing seems to give, roughly, about $4\frac{4}{5}$ times greater bulk of muscle to the *Exocœtus* than to the *Hemiramphus*. With this light it will not be out of place to requote and amplify the one "proof," distinguishing the addition by italics: — "'The pectoral muscles of birds depressing their wings weigh on an average one sixth the total weight of their body, the pectoral muscles of bats one thirteenth, the muscles of the pectoral fins of flying-fish. . . . one thirty-second," *and the muscles of a nearly related non-flying fish only one hundred and fifty-fourth.*

As before, it does not prove that bats or flying-fish flap or do not flap their wings, but it gives a different and, I hope, a proper aspect to the figures which have done duty — of a kind — for so many years.

CONTRIBUTIONS TO MUSEUM TECHNIQUE
I. CATALOGUING MUSEUM SPECIMENS[1]

L. B. WALTON

An essential feature in connection with a museum, is the maintenance of a careful record or history of the objects forming the various collections, since a specimen deficient in data referring to the locality, date and conditions under which it was obtained, is practically valueless in comparison with one correctly catalogued.[2]

The inadequacy of the systems commonly employed, even in prominent museums of America and Europe,[3] by which rarely more than a number, name, and locality of uncertain value, are more or less heterogeneously arranged in cumbersome and often inaccessible volumes,[4] is apparent to any one who has attempted to locate a desired specimen, or when fortunate enough to ascertain the location, to obtain concise information concerning it. This condition of affairs is particularly obvious to the systematist wishing to study the material belonging to a certain group or from a definite area in a museum, for he may indeed be considered

[1] Contributions from the Biological Laboratory of Kenyon College, No. 5.

[2] I have merely given expression to the principle laid down by Goode in his admirable paper on museum administration (Annual Report of the Museums Association, 1895, also republished in the Annual Report of the Smithsonian Institution, 1897) where he says, "A museum specimen without a history is practically without value and had much better be destroyed than preserved."

[3] The museums as well as many other institutions abroad, are subservient to precedents which, under the changing conditions, have too often outlived their usefulness. The remarks of Dr. Meyer in a note on a succeeding page (unintentionally on his part) furnish excellent evidence in corroboration of the above statement.

[4] Both the Field Museum of Chicago and the Carnegie Museum of Pittsburg make use to a limited extent of card or slip catalogues in connection with the book system. From their form and size ($3\frac{1}{2} \times 9\frac{1}{4}$ in the former, $5\frac{1}{2} \times 8$ inches in the latter museum) method of filing, and arrangement of data however, it is questionable whether a decided advance has been made over the old book catalogue.

a fortunate individual if, after the loss of much time examining the collections on exhibition and in storage, both catalogued and uncatalogued, and in consulting the various volumes in which the data are supposed to be kept, he obtains the data which he wishes.[1]

Consequently the following suggestions in respect to the cataloguing (often spoken of as 'registering' or 'recording") of specimens have been brought together primarily with a view toward facilitating the maintenance of such records in museums of Natural History, although it is hoped that they may prove of practical advantage in connection with other institutions of a similar nature. The paper was outlined and partially written while engaged in the rearrangement of certain collections in the American Museum of Natural History, New York, during the summer of 1901. The completion, however, although a brief review was published in the Ohio Naturalist for 1904, has been delayed in order to make further inquiries concerning the systems of cataloguing used in various museums, as well as for the purpose of profiting by a more extended practical application of the method. This latter result has been accomplished in the cataloguing of specimens during the last three years for a foundation of a small museum at Kenyon College. It may be noted that very few changes from the plan first proposed have been rendered necessary.

The literature relating to the subject of cataloguing museum specimens is chiefly conspicuous by its absence, notwithstanding the mass of information in regard to museums and museum administration which has been brought together in the Museum Journal and a few other periodicals devoted to the interests of such institutions, and in the papers by Meyer :00–03, Gratacap :02–03,

[1] In a vigorous article by Bather (How may Museums best retard the Advance of Science, Annual Report of the Museums Association, p. 90–105, 1896) some of the difficulties of locating museum specimens are described as follows. "Many years ago I journeyed to Strassburg on purpose to examine certain specimens that had been described by Mr. de Loriol. The various curators whom I met at the Museum assisted me very willingly throughout three days searching for these specimens, but they could not be found, and I went on my way sorrowing. Arrived at Freiburg, I mentioned the fact to my friend, Professor Steinmann, who suggested that possibly the specimens might have been overlooked as being in the Cartier collection. At considerable expense and inconvenience I therefore returned to Strassburg, and sure enough, there were the specimens carefully obscured."

Murray :04, etc. Meyer (p. 419) briefly outlines the method used in the Field Columbian Museum, while Murray (v. l. p. 264) somewhat naïvely suggests that "As a rule it is of importance that the exact locality from which each specimen has been obtained should be recorded....This does not apply to archaeological objects alone....The date of finding or acquisition is often likewise of importance."

There are nevertheless a few papers which should be mentioned. Hoyle, '91, described the cataloguing of specimens in the Manchester Museum and formulated a system of 'registration' in book form, and of 'cataloguing' through the use of cards. His registration catalogue corresponded to that designated in the succeeding pages as The Department Catalogue. It consisted of fourteen volumes bearing reference letters A–O, beginning with A–Mammals, B–Aves, etc., and ending with N–Mineralogy, and O–Anthropology. Each volume contained space for 12500 specimens and was ruled in perpendicular columns so that space for data concerning 'date,' 'name,' 'locality,' and 'remarks,' was afforded. When a specimen arrived at the museum, the first vacant number in the volume corresponding to the group to which the specimen belonged, was affixed to it and the data concerning it noted in the appropriate column. After the specimen was thus 'registered' (*i. e.*, our Department Catalogue) it was farther catalogued in what Hoyle described as the "Curators Catalogue" (*i. e.*, our Reference Catalogue) by means of which an official record of the contents of the museum arranged according to a natural classification, was maintained. This is very similar to that which I have termed The Reference Catalogue. It consisted of a buff 'family-card' $5 \times 3\ \frac{1}{8}$ inches, on which the name of the family (*e. g.* CIDARIDAE) was written, a gray 'genus card' containing the generic name (*e. g.* Cidaris), and a white 'species card' having the specific name (*e. g.* hystrix) and the mode of preservation, the register number (*i. e.* department number), and locality.

The method of registration presents, in comparison with a card system, the usual disadvantages of the book catalogue as noted on a succeeding page. The absence of a practical means of cross indexing the various volumes by tabs and colored cards

representing systematic divisions, geographical distribution, type specimens, etc., is at once manifest. Furthermore no space is given for noting the authority for identification, date collected, etc., name of collector, etc., for all of which data provision should be made.

The "Curators Catalogue" may be criticized on this same basis. Moreover in a catalogue, the chief purpose of which is that of a reference or finding catalogue, there seems every reason for arranging the cards in alphabetical order in preference to classifying on a systematic basis. Hoyle, himself, in noting some objections to the decimal system proposed by Petrie in *Nature*, mentions the fact that "no specialist is ever satisfied with any other specialist's work." Furthermore unless arranged according to the alphabet as suggested under the Reference Catalogue, it would be of no value to the public. The cards adopted should naturally be of a standard size since odd sizes cannot be perfectly cut by reason of the expensive machinery used. Ordinary 'guide cards' would be much better than the 'genus' and 'family cards.'

Dorsey, '99, reviewed the method of cataloguing used in the Field Columbian Museum of Chicago. As suggested in a preceding footnote, this appears to be more or less of an heterogeneous arrangement of cards, books, and manilla envelopes, which could be much simplified.

Walton, :04, published a brief outline of the present paper noting the division into (a) The Accession Catalogue, (b) The Department Catalogue, and (c) The Reference Catalogue, as well as suggesting the general scope and methods of filing the cards employed in each.

Wray, :05, called attention to the adoption of the card system in the Perak Museum of the Federated Malay States, a result brought about by the unsatisfactory nature of the book method of cataloguing. A single type of card (3×5 inch) was used. This contained the following data: 'Accession No.,' 'Date when received,' 'Place in Museum,' 'Description of Specimen,' 'Where procured,' 'How obtained,' 'Presented by,' 'Bequeathed by,' 'Purchased from,' and 'Collected by.' Duplicate cards were made out, one set being filed numerically as a 'Register,' the other according to the arrangement of the specimens in the museum

(each museum case being given a number, and each gallery a letter, e. g. 17 F) as a 'Catalogue.' The 'Register' evidently corresponds to that which I have designated the 'Department Catalogue,' lacking the method of cross indexing by departments, marginal tabs, and colored cards (when desirable). The 3×5 inch cards used by Wray are too small, while the writing of two sets for each specimen nearly doubles the clerical work involved in the use of an Accession, Department, and Reference catalogue as noted in the following pages, since by the latter method a large number of specimens are usually transcribed on a single department and reference card. Space for certain valuable data is likewise omitted by Wray, something unavoidable however with the small card.

From the first it seemed evident that the card catalogue arranged in unit cabinet sections would furnish the most satisfactory solution of the problem. The value of such a system had long ago been recognized in connection with library and general business methods, where it rapidly displaced the bulky volumes formerly considered necessary to contain various records. The advantages resulting from the use of the card system are obvious, since (1) the required data are presented in a compact and easily accessible form; (2) the capacity is unlimited, useless records can be taken out or new ones added; (3) by varying the position of the tab [1] on the upper margin of the card, as well as by using cards of different colors, a variety of cross reference systems may be employed; furthermore, (4) the form of the card allows the condensation of matter which would extend across one or more pages in a catalogue.

The standard sizes of cards[2] manufactured in America, are 3×5, 4×6, and 5×8, inches, and although other sizes could be made and used, it is well to adopt one of these, inasmuch as the regular card cabinet section can thus be employed as a unit and the special machinery used is particularly adapted for the three sizes. The 3×5 inch cards are too small, and for general purposes the 5×8

[1] The word 'tab' is the term applied to the projecting portion of the upper margin of the card.

[2] The 'standard size' (No. 33), adopted by the American Library Association in 1878 for library use, is 125×75 mm. ($2\frac{61}{64} \times 4\frac{59}{64}$ in.).

inch cards are too large and unwieldy. The 4 × 6 inch card, however, is of sufficient size to contain all necessary data, without being cumbersome in manipulation.

Card cabinets to contain the catalogues may be obtained in various sizes, but by the adoption of the 'unit' card index section containing six drawers adopted for the 4 × 6 in. card, future units may be added as occasion demands, and the cabinet is thus always complete.

Following a chronological order, the data which should be rendered accessible in an adequately catalogued collection, can be separated into three divisions. These are: (A) The Accession Catalogue, containing a general record of all material received by the museum. (B) The Department Catalogue, giving a complete history of each specimen or group of specimens, (a single species, acquired by each department. (C) The Reference Catalogue, having the names of all specimens belonging to each department, arranged alphabetically so that the final disposition of any desired specimen can at once be ascertained.

Of these, the Accession and Department catalogues are essential from a business as well as a scientific standpoint, while the Reference catalogue, although not a necessary requisite, will be found advantageous as a reference index to the specimens, particularly in the larger museums. With the exception of the one pertaining to accessions, which should be in charge of the director of the museum, each catalogue should be controlled by the head of the particular department with which it deals.

While the records considered necessary vary more or less in connection with the needs of the institution and department concerned, they can in general be reduced to the following tabular form, covering the data which may be required in Museums of Natural History.

A. Accession Catalogue (arranged numerically).
   1. Accession number.
   2. Date received.
   3. Description.
   4. How obtained.
      a. Purchase (cost).
      b. Gift.
      c. Exchange.

d. In trust.
e. Museum collectors.

5. From whom received.
6. Address.
7. Transportation number.
8. Collector.
9. Locality where collected.
10. Date when collected (approximate).
11. Correspondence filed under.
12. Remarks.
13. Date of entry.

B. Department Catalogue (arranged numerically)

1. Department number.
2. Accession number.
3. Original number.
4. Number of specimens.
5. Sex.
6. Stage of growth.
7. Scientific name.
8. Authority for identification.
9. Date of identification.
10. Locality where collected.
11. Name of collector.
12. Correspondence.
13. Date when collected.
14. Character of specimens.
15. Remarks.
16. Date of entry.

C. Reference Catalogue (arranged alphabetically)

1. Name of specimen (common name and scientific name,— genus, species,— listed on separate cards).
2. Department number.
3. Character of specimen.
4. Location.
   a. On exhibition. Case No.
   b. In storage. Drawer No.
5. Number of specimens.

The following suggestions have been found valuable in regard to the data and their arrangement on the cards.

A. ACCESSION CATALOGUE.

In this catalogue, all material [1] received or collected at a particular time from a particular source, (an accession), is placed under a single accession number. Thus the catalogue will contain a record of each group of specimens coming into the possession of the different departments in the museums, and by means of a series of cross references, consisting of tabs arranged as indicated

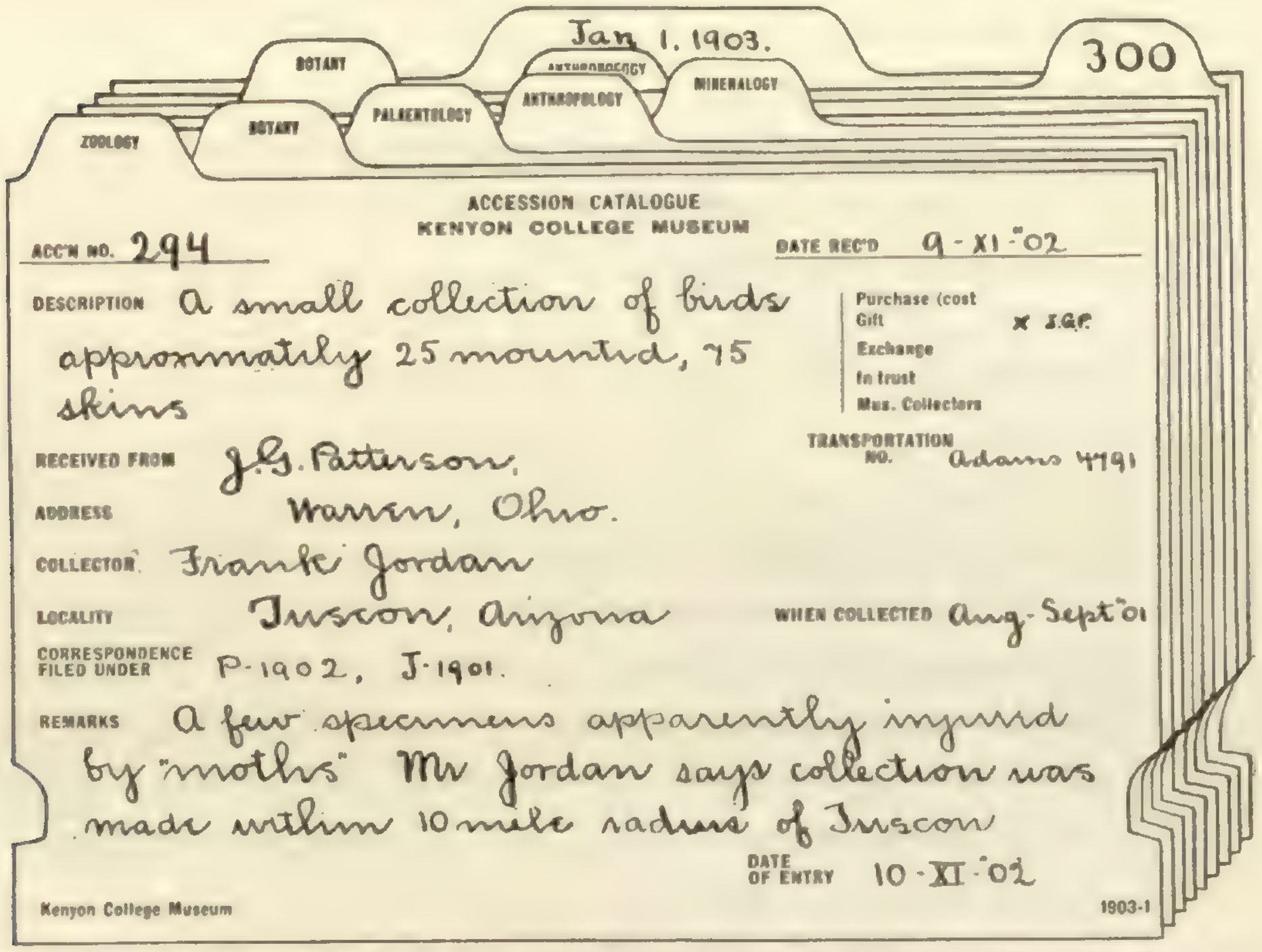


FIG. 1.—Cards (4 ×6 in.) from *Accession Catalogue*. The position of the marginal tabs suggest the various 'departments' into which it is convenient to subdivide a small museum. The arrangement of data is here uniform for each department. A numerical guide card and year card are represented. The commercial (blue) ruling for guide lines is not reproduced.

in the accompanying illustration (Fig. 1), it will be possible to ascertain at any period the data concerning the accessions acquired

[1] While it is equally the same whether one specimen or one million specimens are received, the terms 'particular time' and 'particular place' are necessarily subject to considerable latitude in their interpretation. If certain systems of cross references are used it may be necessary to place a collection under several different accession numbers. For example, if cards of various colors represent geographical distribution (*e. g.* Nearctic, etc.), it would be necessary to use as many accession cards as there were regions represented in the particular collection.

by each department, whether they have been obtained by purchase, gift, exchange, through museum collectors, or in trust, and if by purchase, their cost, as well as the particular fund made use of in connection with their acquisition.

The disposition of each item on the card should correspond to its relative importance. In the following diagram (Fig. 1) a convenient arrangement is suggested.

Classification by Departments.— A classification by departments can be conveniently maintained by having tabs arranged on the cards in as many different positions as there are departments. Thus with $\frac{3}{4}$ inch tabs as in Fig. 1, eight departments may be tabulated.

Accession number.— This should occupy a prominent place, preferably the upper left hand corner, and in order that it may be easily noted, should be written in a large plain figure with black or red ink.[2] The numbers should be serially arranged in accordance with the date of arrival of the accession, and at intervals of one hundred cards, a numbered guide card of a particular color (*e. g.* dark blue) may be inserted. Where no previous catalogue of this nature has been kept, it may be well to have new accessions commence with a number sufficiently large (*e. g.* 1001) to allow the eventual cataloguing of former collections which have come into the possession of the museum [2] in a manner as nearly chronological as possible.

Date received.— The most convenient formula for expressing the date on which an accession is received, is the use of an Arabic numeral for the day of the month and a Roman numeral for the month, followed by the year (*e. g.*, 6–IX–1898 = September 6, 1898). The usual place for the date is the upper right hand margin. At the end of every year, a card can be inserted, on the tab of which the particular year is indicated (Fig. 1). Thus the mate-

[1] It is perhaps unnecessary to remark that in records of this nature india ink should always be employed and cards of the best quality be used. Inks made of aniline colors will fade within a few years.

[2] When accession catalogues have been maintained separately by the departments, the numbers in the new catalogue must be of a higher order than the sum of the previous ones used, provided it is desired to maintain the approximate chronological order.

rial obtained by the museum during any particular period is at all times readily ascertained.

Description of material.— The general nature of the consignment should be indicated, (*e. g.* archeological material, mammal skeletons, fishes) as well as the manner in which it is packed (number of packages, boxes, etc.). In this connection a record should also be kept as to whether the accession is received as a 'purchase,' 'exchange,' 'gift,' 'in trust,' or through 'museum collectors.' This can be readily accomplished by having the above words written on the card and placing a cross in the proper space at the time of cataloguing. When procured by purchase, the price should also be indicated.

From whom received.— The name and permanent address of the person sending the specimens, is to be noted here.

Transportation number.— It is often convenient to have a record of the number or numbers placed upon the consignment by the transportation companies, particularly in the event of breakage or loss of any of the contents of a package or box.

Name of collector.— Many collections are deficient in labels bearing accurate information, consequently it is advisable to ascertain the names of individuals concerned in collecting the specimens, so that if desirable, further data may be obtained. The address of the collector is to be noted, provided it differs from that of the locality where the collection was made.

General locality.— When the collection is a small one from a restricted locality, this can be readily indicated. If, however, a large amount of material is represented, the principal region or regions should be given.

Date when collected.— It is necessary to indicate merely the approximate time.

Correspondence.— In order to readily refer to correspondence, invoices, bills, and other memoranda relating to the accession, it is well to indicate the initial name or number, together with the year, under which they are filed.[1]

Remarks.— Under this heading can be noted the condition of

[1] Madeley :04 presents an elaborate arrangement for the classification of office papers in Museums based upon a provisional decimal system. It seems unfortunate that the standard decimal system (Dewey) was not utilized.

the specimens whether or not the collection contains any forms of particular value (types, cotypes, etc.), as well as other general information.

General suggestions.— In order to record small collections, which may come directly to a department, blank cards may be provided for those in charge, and upon the arrival of such an accession, these should be immediately filled out and handed to the person keeping the Accession Catalogue. Blank cards to be similarly filled out and returned, can be sent to a person from whom an accession deficient in data is received. The system of cross references can be arranged to meet any demand. The method employed as noted above, appears adequate for ordinary purposes. Thus the name of each department is placed on a tab assigned to a particular position, and when the cards are filed, the accessions of a department will be indicated by the corresponding row of tabs. A further subdivision which may be applied to each department is in the use of colored cards. If for example the department of anthropology, possesses three separate appropriations upon which to draw for as many purposes, *e. g.*: (a) Explorations on the North Pacific Coast. (b) The purchase of Michigan Antiquities, and (c) Collections illustrating the life of the Aztecs; all accessions in Anthropology of (*a*) obtained by purchase, or at the expense of the museum from the one fund, can be placed on salmon colored cards, while similarly all accessions of (*b*) and (*c*) obtained from the corresponding appropriations can be placed on buff and blue cards, respectively. Thus at any time the general condition of the various funds of the department can be readily ascertained. Geographical Distribution (*e. g.* nearctic, neotropical, etc. may be represented in a similar manner.

Placing numerical guide cards at intervals of every hundred cards, will greatly facilitate finding any desired accession number. In a catalogue where the width of the tabs makes it possible to have an area at the right from which no tabs project, it is convenient to place the numerical tab as in Fig. 1.

Inasmuch as the majority of accessions cover a quantity of specimens, such a catalogue as the one described can be easily maintained, and the advantages which result through always having correctly classified data accessible are an important item in the making up of reports.

B. DEPARTMENT CATALOGUE.

The department catalogue has the cards arranged numerically in chronological order and should contain concise information concerning each specimen, or group of specimens belonging to the same species which were obtained at a definite time and place. In the smaller museums the material may be grouped under departments of Zoology, Botany, Palæontology, etc. as represented by

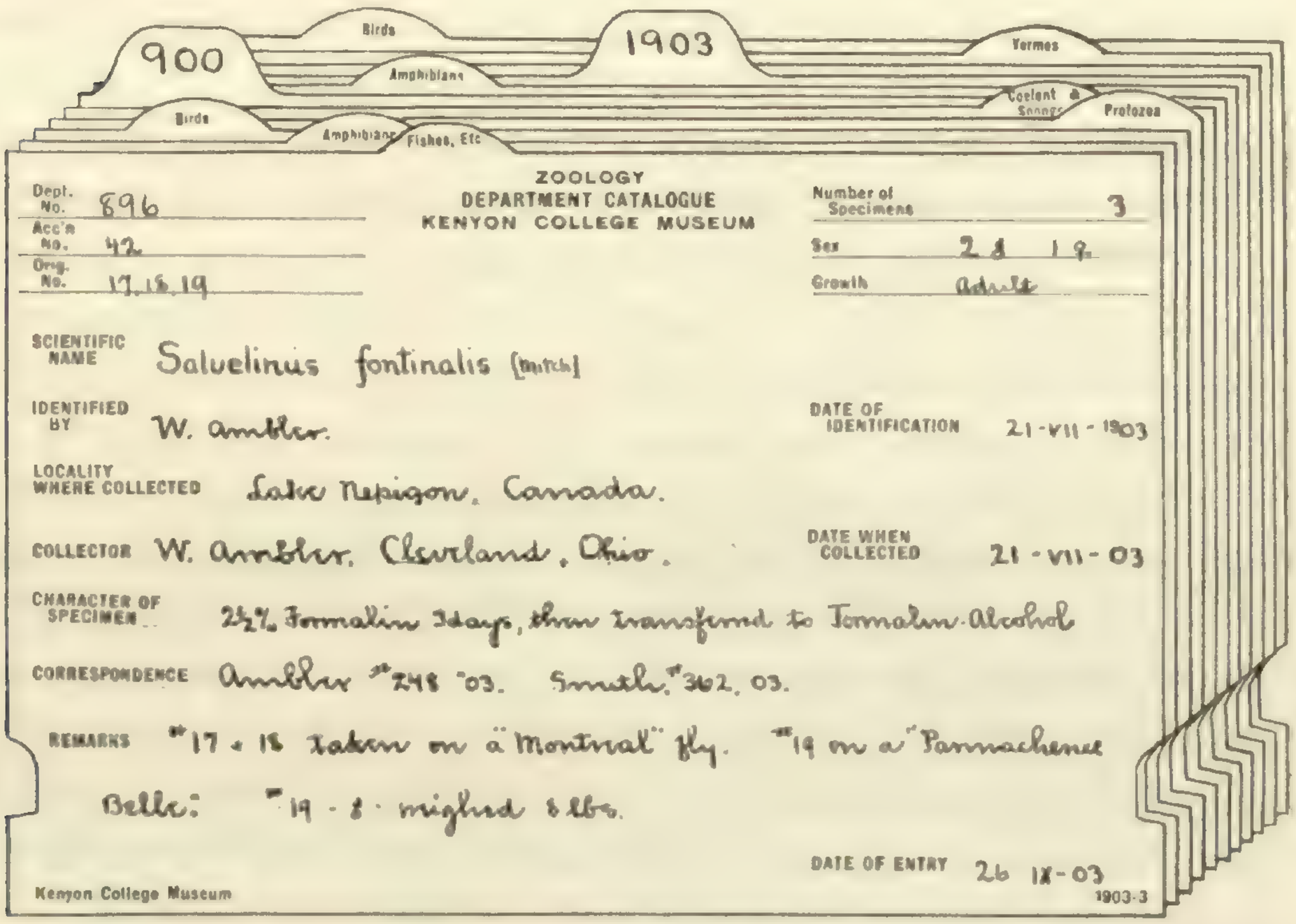


FIG. 2. *Department Catalogue*, Zoology, cards (4×6 in.), showing arrangement of data, and method of systematic cross indexing by position of small marginal tabs (*e. g.* Fishes, Amphibians, Birds, etc.). The color of the card furnishes a second system of cross reference illustrating the geographical distribution (*e. g.* white = Knox Co. Ohio; salmon = Ohio exclusive of Knox Co.; buff = all territory outside of Ohio. Numerical and year guide cards are also shown.

the Accession Catalogue (Fig. 1) each with its separate department catalogue. In the larger museums, however, it will often be advisable for each department to have several sub-departments or group catalogues having the rank of departments. For example the department of Zoology may maintain catalogues of Vertebrate and Invertebrate Zoology, or of Pathological preparations, Neurological specimens, etc., or on a systematic basis it may have a catalogue for each phylum or branch of the animal and plant kingdoms. The cross-reference classification by means

of tabs, however, as represented in the department catalogue (Fig. 2) will usually be sufficient in the smaller museums.

Here the arrangement of data will meet the needs of the average department. Near the middle of the upper margin of the card should be placed the name of the particular department to which it refers, together with the name of the institution. If the department is large so that group catalogues are necessary, this should also appear, *e. g.* Zoology Department Catalogue, South African Museum, Birds.

Systematic cross reference classification by tabs. — The classification adopted will depend on the nature of the catalogue. If half-inch tabs are used on a 6 inch card twelve divisions are possible which in the zoological department cards above consist of 1. Mammals, 2. Birds, 3. Reptiles, 4. Amphibians, 5. Fishes, etc. 6. Tunicates, 7. Echinoderms, 8. Articulates, 9. Mollusca, 10. Vermes, 11. Coelenterates and Sponges, and 12. Protozoa. For certain reasons an arrangement in the reverse order would be more logical. In a botanical catalogue one could choose between the older classification of Eichler, 1883, where a somewhat arbitrary grouping gives us the 1. Algae, etc., 2. Lichens, 3. Bryophytes, 5. Ferns, 6. Gymnosperms, and 7. Angiosperms, and the recent one of Engler,[1] 1904, with thirteen groups and 35–40 classes. The classification adopted in the other department catalogues, Palæontology, Anthropology, etc., will in a similar manner represent to a more or less extent the personal equation of the curator under whose supervision they are maintained.

Geographical cross reference classification by colors.— Geographical distribution may easily be indicated by having cards of a particular color represent definite areas. Such an arrangement does not appear to render the card system so complex that it is disadvantageous, although over-systematizing is a danger which confronts any general method.

If the collection is local in its character, the majority of specimens being obtained from a given state, an excellent arrangement is that of having all specimens from the county in which the collection is located, catalogued on white cards; all specimens from

[1] Engler, A. 1904. Syllabus der Pflanzenfamilien, 4th edition, Berlin.

the state excluding the county, catalogued on buff colored cards while other specimens from localities outside of the state would be catalogued on salmon [1] colored cards. In the larger museums where collections are made up of specimens from different parts of the world, certain colors can be used to represent various regions, (nearctic, neotropical, palæarctic, etc.). Types, cotypes, etc. could be catalogued on cards having the right half red, the left half in accordance with the color representing the particular geographical distribution.

Department number. — A single department number will cover a series of specimens of the same species, which have been obtained at the same time in a particular locality. This method is more satisfactory than assigning a number to each individual specimen inasmuch as time would be lost by such a method and no particular benefits result. Should the occasion arise at a later period, a separate number may be assigned to any specimen.

Accession number.— This should be indicated on the card, in order that general information regarding the collection may be obtained at any time. The accession number and department number may be indicated in connection with the specimens as a fraction (*e. g.* $\frac{294}{896}$) whose numerator represents the accession number, and denominator the department number, or as a decimal (294.896), or the accession number may be entirely omitted from the specimens, since a reference to the department card will furnish it when desired.

Original number.— This is the number which a specimen may possess on its arrival. Often times it will be the field number placed on it at the time when it was collected or it may refer to a number assigned in a previous collection.

Number of Specimens.— This is essential in order to know the amount of material in any collection. When duplicates are used for exchange, the former number should be crossed out and the new one substituted, while, at the same time, a reference number referring to the exchange may be added.

Sex.— The sex can be designated by the conventional signs, ♂, ♀, ☿, representing, male, female, and hermaphrodite forms.

[1] These colors are suggested inasmuch as the majority of manufacturers of cards in the United States make them in four standard colors, white, buff, salmon, and blue.

Growth.— Embryo, young, adult. Measurements, weight, etc.

Scientific name.— In systematic work of this nature the generic followed by the specific name must be used.

Authority for identification.— This is an important item which is too often omitted from the average museum catalogue. If a specialist subsequently verifies a name previously given, this should also be noted. In case the name is found incorrect a new card is to be written.

Date of identification.— It is well to have this information available.

Locality where collected.— Too much care cannot be exercised in accurately indicating the locality from which specimens are obtained. It is safe to say that every museum has among its collections material which would be of the utmost value, provide the locality, even within a few hundred miles, could alone be ascertained. Unfortunately in most cases of this kind, it is the collector who is at fault. The cataloguer must rely on his data.

Name of collector.— Inasmuch as the 'personal equation' must be taken into consideration, the name of the collector is indispensable. Furthermore it often furnishes a clue to the history of a specimen when all other means have failed.

Correspondence.— Letters, etc., pertaining to the particular specimens can be indicated as suggested in the accession catalogue.

Date when collected.— This can be indicated as in the accession catalogue.

Character of specimen.— The nature of a specimen, whether a skeleton, an anatomical preparation, a mounted skin, etc., should be given. If preserved in a special manner it is well to indicate the formula, *e. g.* 5% formalin; 70% alcohol; killed and hardened in chromosmic 3 hours, preserved in 95% alcohol, etc. Explicit notes here will in the end well repay the time spent in making them. The back of the card will afford additional space, if needed.

Remarks.— This space is only to be filled out when there is something of particular importance to be noted concerning the specimen, and of a nature which cannot be covered under the other records.

General suggestions.— The data, as well as their arrangement on the cards, are naturally subject to various changes, in order to conform to the requirements in different museums. It is well to have a blank space for each item of information concerning the specimen, although often unnecessary, or even inadvisable, provided there is reason to doubt its accuracy, to fill it out. As in the Accession Catalogue numerical guides should be placed at intervals of one hundred cards, while 'side locking cards' are recommended.

C. REFERENCE CATALOGUE.

The Reference Catalogue may with equal propriety be termed a finding list, since its purpose is that of indicating the location of

ZOOLOGY
REFERENCE CATALOGUE
KENYON COLLEGE MUSEUM

NAME Cryptobranchus allegheniensis Daud

Department Number	Character of Specimens	Exhibition		Storage		Total	Department Number	Character of Specimens	Exhibition		Storage		Total
		No. of Spec.	Case No.	No. of Spec.	Draw'r No.				No. of Spec.	Case No.	No. of Spec.	Draw'r No.	
475	Alcohol 75%	3	12	1		3							
498	Formalin 3%			1	27	1							
507	" "			4	27	4							

FIG 3.—Reference Catalogue card (4×5 in.). One card will usually contain data referring to 50–100 specimens. The cards to be arranged alphabetically, the scientific and 'common' names to be on separate cards. An alcove or hall letter may be added to the case number. The permanent position of the card in the drawer may be assured by use of a central rod.

each specimen which belongs to the particular department in the museum. The cards are arranged in alphabetical order, both the scientific name (generic followed by specific name in the case of biological specimens), and the common name having a place on separate cards, the latter, however, referring to the former,

(*e. g.* opossum, see Didelphys. Furthermore, the reference card indicates the number of specimens of each species on exhibition, or in storage, giving the number of the case or storage drawer in which they are to be found.

A single card will usually contain the data concerning all material belonging to a particular species, consequently the time involved in maintaining a Reference Catalogue is an unimportant item, the data (except location of specimens) being readily obtainable at any time from the Department Catalogue.

The Reference Catalogue should be located in the principal room containing the collections to which it refers, where it will be readily accessible to each of the three classes of people for which a museum primarily exists: (a) the specialist, (b) the amateur, and (c) the general public.[1]

One method for arranging the data for a reference catalogue, is shown below (Fig. 3).

Systematic Cross Reference Classification by means of Tabs.— An excellent method which meets the usual requirements, is that of having the tabs arranged as in the Department Catalogue. Geographical cross reference by colors cannot be used inasmuch as one card will often contain specimens from widely separated localities.

Name of specimens.— Both the scientific name and the common name should be given, the former on the card containing the data, the latter on a separate card referring to the generic or specific name of the particular species. (*e. g.* Brook Trout, see *Salvelinus fontinalis,* Pickerel, see *Esox,* various species). By placing the common name on cards having a particular color they may be readily distinguished.

Department numbers.— Inasmuch as the department numbers will be placed on all material, this will serve to establish the identity of the specimen sought, and in case further data is required, the corresponding number in the Department Catalogue can be consulted.

Character of Specimens.— In alcohol, mounted, skeleton, skin, etc.

[1] See Bather, F. 1904. The Functions of a Museum; a Re-Survey. Pop. Sci. Mo., v. 64, p. 210–218.

Exhibition, Storage, etc.— The location of a specimen is indicated by the particular column under which it is placed. If on exhibition, the number or letter of the case [1] will be given. Alcoves or galleries may be designated by letters. If on storage, the location will be similarly designated.[2]

Total number of specimens.— These columns will indicate the total number of specimens of a given species [3] belonging to the museum. If customary for the institution to make many exchanges a balance column may be added, which will show the material on hand as well as that exchanged.

The necessary steps incident to the cataloguing of a collection which has been received may now be outlined as follows.

a. Catalogued as an Accession.
b. Placed in charge of a department.
c. Catalogued in a Department Catalogue and given a department number.
d. Identified and labelled. This data then added to the department card.
e. Placed on exhibition or in storage.
f. Reference Catalogue filled out from data on department card.

The first three items should be attended to at once. A considerable interval will often elapse however before final desposition of the specimen is made.

It would seem that only two general objections can be urged against any system similar to the one proposed, namely; (1) The plea that too much time will be occupied in the preparation of such a catalogue, and (2) a certain inherent condition which precludes the adoption of new ideas. The only answer that need be given

[1] If the case is a large one and contains a quantity of specimens, it may be convenient to indicate the number of the shelf, etc.

[2] The practice of having separate department catalogues for the exhibition and storage series, is to be criticised. Different species thus possess identical numbers, and when it becomes necessary to transfer a specimen which has outlived its usefulness for exhibition purposes, to the storage collection, complications at once ensue.

[3] When it becomes desirable to include a collection in a guide book to the museum or to issue a general catalogue of the specimens, the question involved is merely that of selecting the data here classified.

to the former is that the space occupied by a specimen unworthy of being properly recorded, is more valuable than the specimen itself, while to the latter no reply is needed.

It is unnecessary and often inadvisable to at once reduce former catalogues to a card system. Incoming material can be catalogued on the cards, and as the opportunity allows, data from the previous records can be transferred to cards.

Conservatism [1] is a valuable factor in connection with all scientific work. It has its limitations however, and in order to make definite progress in any direction, old methods must give place to new ones — the fittest will survive.

KENYON COLLEGE, GAMBIER, OHIO. Dec. 1, 1906

[1] Meyer, (:00–01) in his excellent review of the museums of the eastern United States depreciates the lack of uniformity among the various American museums in respect to the installation of the collections. In reply to this criticism however it might well be suggested that to a certain extent at least this lack of uniformity is an indication of healthy activity. It is not considered necessary in this country to cling to traditional ideas which are too often brought to the attention of one visiting European museums. New methods of dealing with well known problems are sought and evolved — and if their value is proven — they are adopted.

Since the above paragraph was first written (Aug. 1901) Dr. Jordan in his presidential address before the members of Sigma Xi (Dec. 31, 1903) expressed similar ideas regarding this tendency which he had noted. "In France, in Germany, even in England, the tradition of great names, the customs of great museums, largely outweigh the testimony of the things themselves.— The willingness to adopt new ideas is, broadly speaking, in proportion to the spirit of democracy by which a worker is surrounded."

BIBLIOGRAPHY

Dorsey, G. A.
'99. (The Cataloguing of Museum Specimens), American Anthropologist, n. s., 1, p. 473.
Meyer, A. B.
: 00–01. Ueber Museen des Ostens der vereinigten Staaten von Amerika. R. Friedlander und Sohn, Berlin. (Also see translation in Report of the U. S. National Museum for 1903, p. 311–808 with 40 plates).
Hoyle, W. E.
'91. The Registration and Cataloguing of Museum Specimens. Annual Report of The Museums Association, Cambridge, England.
Madeley, Chas.
: 04. The Classification of Office Papers. Mus. Jour., v. 4, no. 3, p. 73–95.
Murray, David.
: 04. Museums, Their History and their Use. 3 vols., J. MacLehose and Sons, Glasgow, Scotland.
Walton, L. B.
: 04. The Cataloguing of Museum Collections. Ohio Naturalist, v. 4, no. 3, p. 62.
Wray, L.
: 05. A System for the Registration of the Contents of Museums. Museums Journal, June, p. 407–412.

SOME SOUTH AMERICAN ROTIFERS

JAMES MURRAY

The undernoted rotifers were obtained from moss kindly sent to me by Mr. N. D. F. Pearce, of Cambridge, England, in the early summer of 1906. The moss was sent from British Guiana. The locality from which it came was unknown, but it was somewhere in the interior.

A portion of the moss was still moist, but most of it had been dried. The majority of the species were got from the dried moss.

As is usual when dried moss is examined after a lapse of some time, most of the rotifers found belonged to the order Bdelloida. Of this order 13 species were distinguished; 11 of the species were already known, most of them being common and widely distributed species. One, *Callidina perforata*,[1] was only recently discovered in India, and a very distinct variety occurred more abundantly than the type. *C. multispinosa* was represented by a variety, probably of specific value. Two new species are here described.

Four species of the order Ploïma were also found,— one Colurus, two Monostyla,— and one Diglena. I was unable to determine any of these.

Order Bdelloida

Callidina angusticollis Murray (:05).— Very abundant. All the examples belonged to the type, or to a small variety. The Indian variety *attenuata* did not occur.

C. perforata Murray.— The most abundant species in the collection. The type (Fig. 1) was fairly plentiful, but a variety, described below, was much more so.

C. p. var. **americana** var. nov. (Figs. 2–3).— Case smaller than in the type, length 106 μ (type about 136 μ). Posterior process

[1]Murray, James, "Some Rotifera of the Sikkim Himalaya." *Journ. Roy. Micr. Soc.*, 1906.

sharply marked off by abrupt constriction, not turned to dorsal side as in the type, but in line with the axis of the case; — perforation towards ventral side (dorsal in type). Dorsal plicæ of the case not distinct, but an obscure tesselation or coarse stippling instead. As in Indian examples, empty cases usually lacked the ventral wall, as though some enemy had found this part vulnerable.

C. constricta Duj. ('41).— Plentiful.

C. aspera Bryce ('92).— A few examples.

C. habita Bryce ('94).— One example, living.

C. quadricornifera Milne ('85–'86).— One small hyaline example.

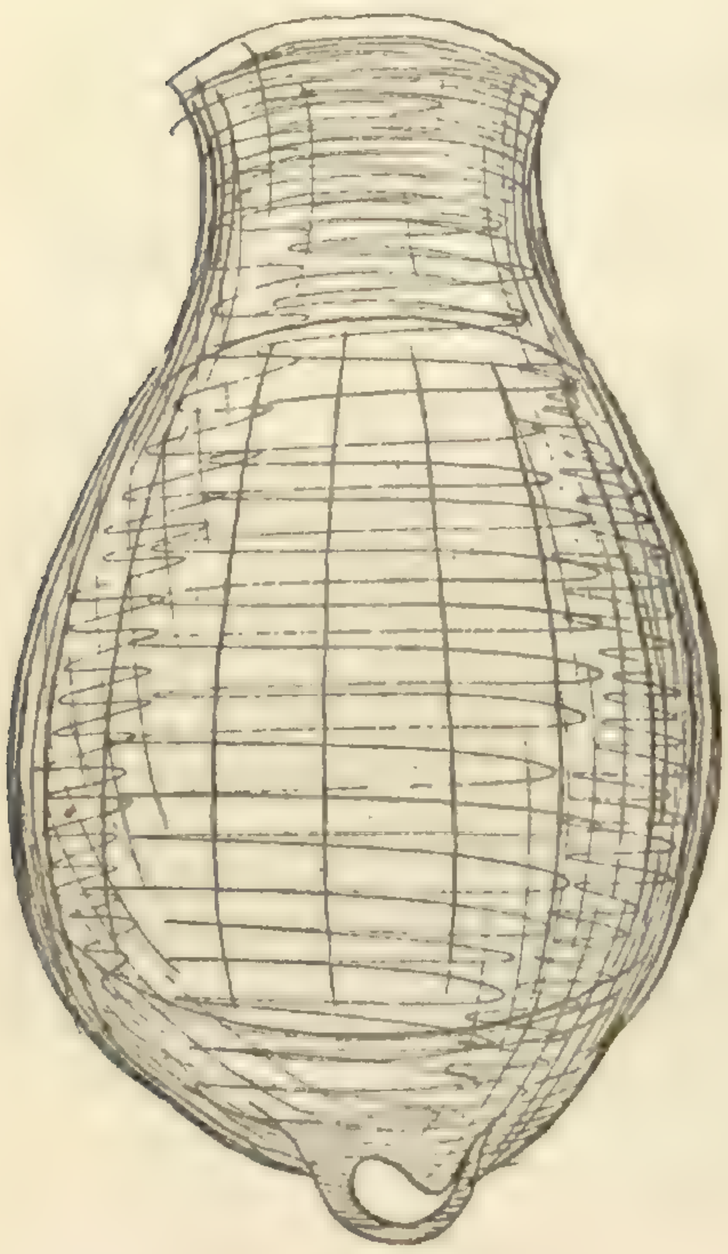


Fig. 1.

Fig. 2.

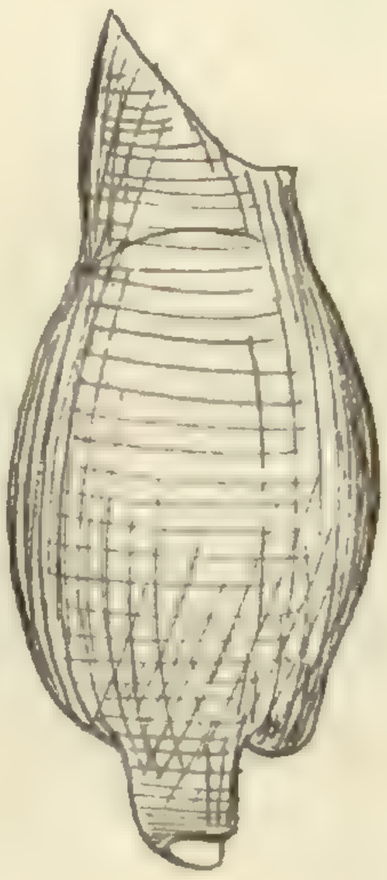


Fig. 3.

Callidina perforata Murray.

C. multispinosa Thompson ('92).— In Britain I have found this species variable only within narrow limits. In various warm countries I find many forms related to this species, sufficiently distinct and apparently constant, which are probably distinct species. They are so numerous that I think it would be well to make further comparisons of them before deciding how many of these forms are good species, and I make all provisionally subordinate to *C. multispinosa*. In British Guiana the type was not found, but two varieties were frequent. One variety has all the spines very short. It has a superficial resemblance to *C. papillosa*,

but the arrangement of the spines shows that it belongs to this species. This variety is also found in India and Africa.

C. m. var. **crassispinosa** var. nov. (Fig. 4).—Long anterior spines few, usually 4 on each side, the 2d and 4th of these much thicker than the others. The lateral spine of the anterior row on the central segments of the trunk large and very thick. Skin strongly stippled or papillose.

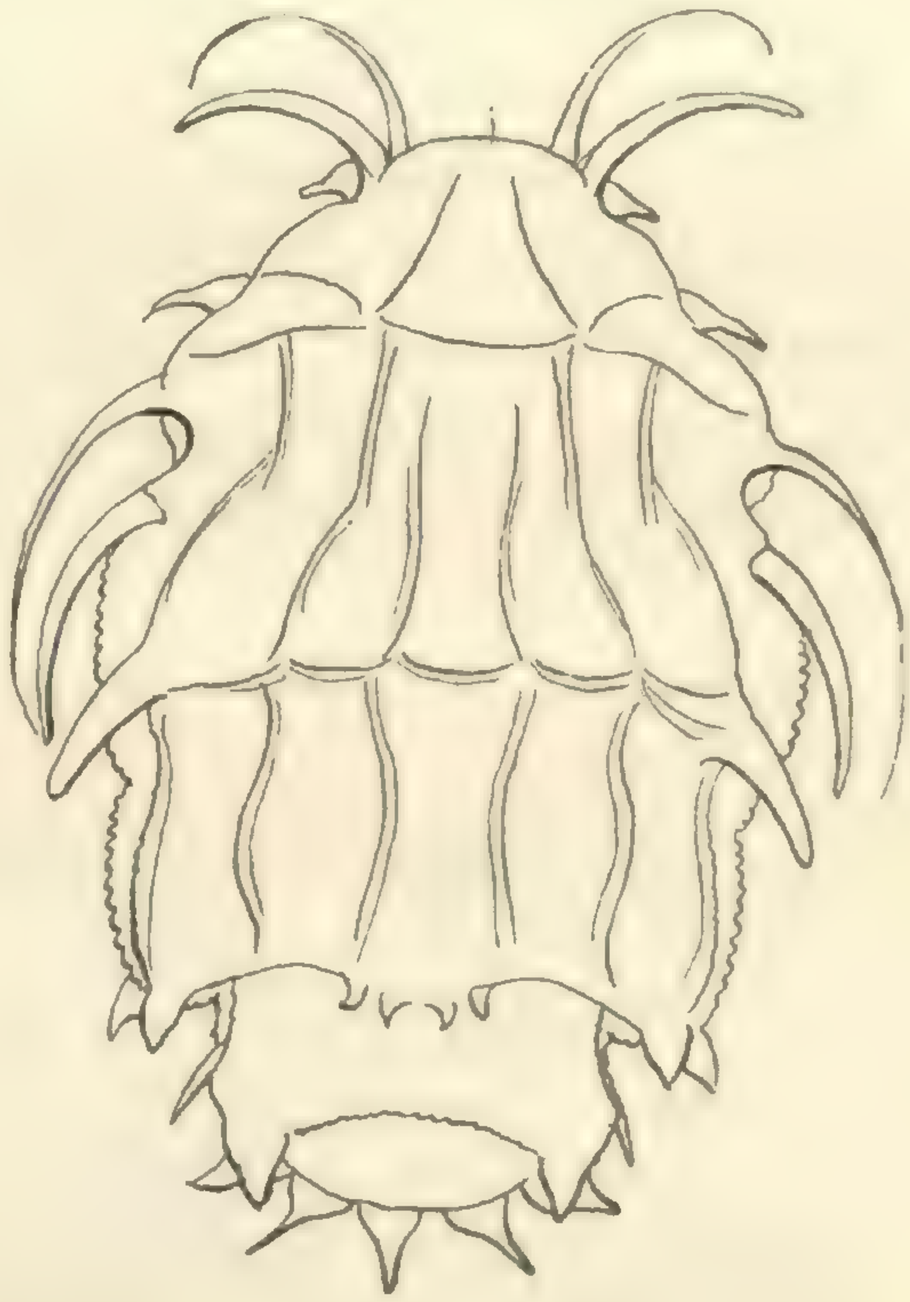


Fig. 4.

Callidina multispinosa, var. *crassispinosa*.

Other smaller differences from the type will be better understood from the figure. There was no variation from this arrangement of spines in all the examples seen. The variety is much smaller than the type. About 6 examples seen.

C. ehrenbergi Janson ('93).— One living example.

C. tripus n. sp. (Figs. 5–7)

Specific characters.— Small, 240 μ long, hyaline or whitish, with pale yellow stomach, food not moulded into pellets. Head small, corona 40 μ wide, less than collar and about half diameter of central trunk, discs touching, central process of upper lip single, truncate. Length of antenna $\frac{1}{3}$ diameter of neck. Jaws 18 μ long, teeth 2/2, very thin. Foot 4-jointed, spurs narrow, tapering, divergent; toes large and long, the two ventral put out and drawn in, in the usual manner, when making the step, the dorsal kept always extended and forming with the spurs a tripod. Dorsal skin folds faint, few, lateral deeper. The striking peculiarity is the tripod, which is unique in the order. Otherwise the animal comes nearest *C. ehrenbergi* Janson, from which it is distinguished by the smaller head, closer discs, and truncate upper lip. Abundant.

C. speciosa n. sp. (Figs. 8–10)

Specific characters.— Very small, 163 μ feeding to 238 μ creeping. Head very small, diameter of corona 26 μ, of prominent collar 38 μ. Food not moulded into pellets. Teeth 2/2. Anal segment with lateral prominences. Foot 3-jointed, first joint with lateral processes, spurs small, tapering, divergent. Toes three. Dorsal longitudinal and ventral transverse skinfolds forming symmetrical pattern, which is constant. Length of antenna half diameter of neck.

The most distinctive character is the pattern formed by the

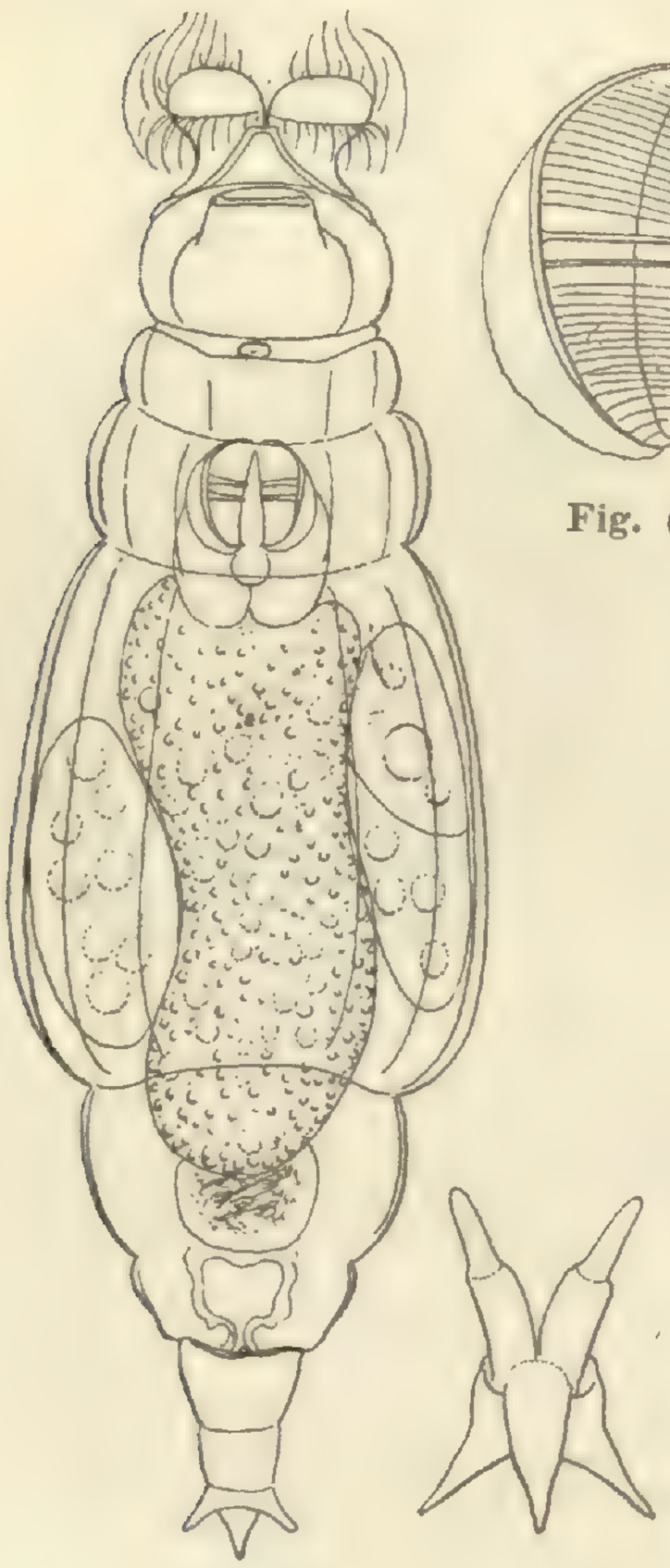


Fig. 5.

Fig. 6.

Fig. 7.

Callidina tripus n. sp.

Fig. 8.

Fig. 10

Fig. 9.

Callidina speciosa n. sp.

skinfolds. Many species have a similar pattern formed by the dorsal wrinkles, but no other species has the ventral surface so ornate. Apart from this character it has no close resemblance

to any other species. Those which approach it in general form and dorsal wrinkling have larger heads with separated discs.

Not abundant, about a dozen examples seen.

Rotifer longirostris (Janson) ('93).—Several examples of the type were found, but none of the Indian varieties occurred.

Adineta gracilis Janson ('93).— Not plentiful.

A. vaga Davis ('73).— Rare.

LITERATURE

Bryce, D.

'92. On the Macrotrachelous Callidinæ. *Journ. Quekett Micr.* Club, ser. 2, vol. 5, p. 15.

Bryce, D.

'94. Further Notes on Macrotrachelous Callidinæ. *Journ. Quekett Micr. Club*, ser. 2, vol. 5, p. 436.

Davis, H.

'73. A New Callidina. *Month. Micr. Journ.*, p. 201.

Dujardin, F.

'41. Zoophytes Infusoires, p. 658. Paris.

Janson, O.

'93. Rotatorien-Familie der Philodinæen, Marburg.

Milne, W.

'85–'86. Defectiveness of the Eye-spot, etc. *Proc. Phil. Soc. Glasgow*, vol. 17, p. 134.

Murray, J.

:05. A New Family, etc. *Trans. Roy. Soc. Edinb.*, vol. 41, p. 367.

Thompson, P. G.

'92. Moss-haunting Rotifers. *Science Gossip*, p. 56.

MERISTIC HOMOLOGIES IN VERTEBRATES

J. S. KINGSLEY

One of the most difficult problems in vertebrate morphology is to explain the serial homologies between the different groups. In the lower segmented animals these difficulties, although they exist, are far more simple and are far more easily explained. Thus no one has any doubt that the tenth or the fifteenth somite of Homarus is the exact equivalent of the serially homologous somite of Cancer. Between the larger Arthropodan divisions the task of comparisons of somites is possibly not so easy yet all attempts at drawing homologies between, say, a hexapod, an arachnid and a crustacean, are based upon the assumption of exact serial equivalency. It is true that one author or another has at times suggested the possibility of intercalation or elision of a somite, but these have been mere suggestions and have usually been discarded in the discussions.

In the vertebrates this comparison is more complicated. We are forced to assume that the shoulder girdle and fore limb of the frog are the homologues of those of man, although their connections are with entirely different somites when serial position is taken into account. In the case of the pelvic arch the numerical disparity of the corresponding somites is even greater, but in either case the identity of structure of arch and limb is so great that doubt of homology is practically impossible. How then has it come about that say the twelfth somite of the Amphibian is not homologue of the twelfth but of more nearly the twentieth of man?

In Gegenbaur's hypothesis that the girdles are derived from branchial arches and that these have migrated backwards over the post-cranial somites we have a possible explanation of these problems of the relations of girdles to body segments. The backward migration has been arrested at different points in the various

groups. But this explanation will not suffice for other cases, hence the probability that it is true for none.

In the frog as in all Ichthyopsida, there are but ten cranial nerves, while in the mammals there are twelve. There is no doubt that as far back as the tenth the nerves are exactly homologous in Amphibia and in the mammals. Relations to brain and to points of distribution place this beyond question, but what shall be said of the mammalian eleventh and twelfth? Are both of these nerves from the post-cranial region which have been transferred to the skull? If so, does it not follow that the cranium in the higher vertebrates is not the exact equivalent of that in the lower? and that the differences have been brought about by the transformation of cervical into occipital vertebræ. If this, in turn, be so, are the occipital bones of the frog homologous with those of the mammal? Or are the basi-, ex- and supra-occipitals of the one merely analogous of those of the other? Is Huxley's argument for the derivation of the mammals from the Amphibia because of the double occipital condyles in the two groups based upon analogies rather than on true homologies? Are the condyles in Amphibia and Mammals not homologous but rather homoplastic formations?

Carrying this matter further back in the body, how are we to explain that apparent shifting of the pelvis in such a form as Necturus as described by Bumpus, Parker and others? Are somites ten, twenty and the like exactly equivalent in the normal and aberrant forms? And has there been an actual shifting of the pelvic girdle from one somite to the next in some individual? Or has there been an actual intercalation of vertebræ, the one to which the ilium is attached being constantly the same morphologically if not serially? Or, lastly, have the limbs and their arches arisen from a continuous fin fold and has every somite which contributes to that fold the potentiality of limb formation with all that this implies?

To take another case. In Amphioxus there are a large number of gill slits, a number which is doubled during development by the formation of the 'tongue bar.' Right behind the last gill slit comes the entrance of the hepatic duct into the alimentary tract, there thus being no œsophagus nor stomach intervening between

the pharynx and the liver. Is this to be explained by saying that in the vertebrates the posterior gill clefts of Amphioxus have closed and that the space which they occupy has become converted into stomach and œsophagus? In other words are these formations of the vertebrate tube the homologues of a part of the gill region of the acraniate?

Then, too, what are to be done with cases of increased numbers of gill slits; the Notidanids with six or seven, the Californian Bdellostoma with its variable number, and Amphioxus itself? This question is wholly apart from that which discusses the relations between metamerism and branchiomerism.

Numerous other similar questions will readily suggest themselves to all. There is no reason for enumerating them here. The problem is, how are they to be explained. Must we find a separate explanation for each or can we find some one principle which will account for all?

This article is to be regarded in the light of a suggestion rather than a full reply with demonstrations of validity. I have no proof, other than analogies and the fact that the hypothesis here presented answers all the demands of the problem, that the explanation here advanced is the true one. It must be tested and the tests are not easily made.

In the invertebrate segmented animals there is, at the beginning, no metamerism. It appears later during growth, and in numbers of forms it is found that the segmenting tissues are produced by budding from groups of cells at the posterior end of the embryo. These are most familiar in the annelid teloblast and are scarcely less well known in the Insects and Crustacea. Their number varies between wide limits, but for the present purposes the most important points concerning them, aside from their budding capacities, are their position in a more or less plainly marked transverse band and their situation at the extreme posterior limit of the growing embryo. Extensive examination of the literature has not shown similar budding cells in the Cuvierian group of Articulata in other places than the tip of the growing embryo, with the exceptions noted below.

It follows then that in these teloblasts and their equivalents are the full potentialities of the future somites. From them arise

all the cells which are utilized in every structure which is metamerically repeated, the material for the new somite not being budded from any pre-existing somite, but always just in front of the hinder end of the body.

This applies strictly to all cases which are known to me in the arthropods as well as to most of the annelids; but in a few of the latter group modifications occur in the process which have great interest for us. As is well known in a number of annelids asexual reproduction by transverse division occurs. At one or more points in the body a new head may develop with the eyes, appendages, etc., characteristic of the anterior end of the worm, these features arising from a somite which in its earlier stages is apparently normal and like its fellows on either side. Then, just in front of this new head the worm divides and two worms, each with fewer somites than the original one, are produced and from this time onward lead an independent existence.

Of these only the anterior worm need now be considered. After the separation the segment which was just in front of the new head of course becomes the terminal somite of the new worm. The worm now increases in length and the new somites are formed by material cut off from the terminal somite which thus must have within it the equivalent of the teloblasts of the embryo.

From these facts it seems logically to follow that at least certain somites in the body have the potentialities of forming material for additional somites and must contain within them the same physiological possibilities as the original teloblasts from which they arise. In other words, in the annelid before the beginning of the transverse division the capacity for producing new tissues was located at more than one point in the body, but it was not exercised until after the asexual reproduction was well advanced.

In the case of the Naides the somites thus produced are all similar in character but in such instances as Protula, where heteronomous somites occur, the division of the worm is accompanied by the formation of new somites which differ in kind.

The application of these facts to the various types of meristic variation which occur in annelids need not be discussed here, but I think it is apparent that they will in part explain some of them. I do not mean to say that they reveal first causes but they do point

out the mechanism involved and may be used to reduce all to a common rule.

In the same way the assumption that there are similar budding zones at various points in the vertebrate body will explain the various conditions outlined in the statement of the problem. In the vertebrates there is a continuous addition of new somites at the posterior end of the body as in the arthropods and annelids, implying the existence of the equivalents of teloblasts at the posterior end. The assumption of budding zones at other points will explain the other features noted. Such a zone in the occipital region will allow us to explain the difference in the number of cranial nerves in the mammals and in the Ichthyopsida and yet allow us to accept the homology of the occipital bones throughout the vertebrate series. The additional nerves are thus to be regarded not as transferred from the neck but as new or intercalated structures. In the same way we may explain the varying number of vertebræ in the different regions and allow at least one of the pelvic vertebræ to be regarded as a fixed point and may be relieved of any assumption of a shifting of the girdles. It will also explain many anomalies such as the attachment of the two halves of the pelvis to different vertebræ and the increased number of lumbar or thoracic vertebræ in man.

This is to be regarded solely as an hypothesis. So far as I am aware no one has seen such budding zones in any vertebrate. In fact it is extremely probable that there is no such well defined zone as is found in the band of teloblasts of the crustacean. It is to be regarded rather as a series of assumptions, based in part upon analogies, which, if true, would explain the questions with which the present note began. The hypothesis is presented as a suggestion to stimulate investigation and criticism upon an interesting and difficult subject.

ON THE OSTEOLOGY OF THE TUBINARES.

R. W. SHUFELDT.

I. Historical.

Few of the groups of Birds have a more interesting literature than this Suborder.

As early as 1827 M. L'Herminier placed the Tubinares together in a family of birds (28th) and classified them upon the characters of their sterna, assigning them to three sections; (1) the smaller Petrels in which the xiphoidal end of the sternum was entire or nearly so; (2) the Albatrosses, where it presented a shallow notch upon either side of the carina; (3) those Petrels in which two well-marked notches occurred on either side of the sternal keel.[1]

M. M. Hombron and Jacquinot in the year 1844, added something to our knowledge of the Tubinares,[2] and they classified the group upon the morphology of their palates, tongues, and beaks. In one genus they placed the three genera Diomedea, Puffinus and Priofinus, in another, the genus Prion, and finally, in their third genus,— Procellaria. By them Pelecanoides was removed from the Procellaridæ, and placed in the Alcæ near Alle, which they considered its nearest relative (*A. nigricans*). Five years later Gray and Mitchell (1849) divide the Procellaridæ into the Diomedeinæ and the Procellariinæ, and the last named into 5 genera (Prion, Pelecanoides, Thalassidroma, Procellaria, and Puffinus), the group constituting the fourth family of their Anseres.[3] In his Conspectus, Bonaparte divides the Procellaridæ into the Diomedeinæ, Procellariinæ, and the Halodrominæ; the second

[1] Recherches sur l'appareil sternal des Oiseaux, pp. 79–81. v. iv. Paris, 1827.

[2] Remarques sur quelques points de l'anatomie et de la physiologie des Procellarides, et essai d'une nouvelle classification des ces oiseaux, *Compt. Rend. de l'Acad. Sci.* xviii, 1844, pp. 353–358.

[3] The Genera of Birds, iii, pp. 646–650.

subfamily being subdivided into five lesser groups.[1] But a few years later (1864–66) this constitution was followed by the far more accurate work of Coues, though that distinguished ornithologist complains of "having suffered not a little from imprudence in believing Bonaparte," whom to some extent he followed, but upon the whole has given us a more natural classification of the Tubinares.[2]

Both Bonaparte and Coues based their classification upon the topographical anatomy of the birds of the suborder we are now considering, but this was not the case with Eyton nor with Milne-Edwards; nor with Huxley who followed them.[3] All these distinguished authors dealt more or less thoroughly with the osteology of many of the Tubinares, as well as with such characters as procellarine species presented externally. Eyton figured the bones of the skeleton of several varieties of Albatrosses, and forms related to them. Milne-Edwards pointed out the relations existing among Petrels, Gulls, and the Steganopodes; showing that the first two were more or less closely akin, and both more remotely related to the last-named group of Birds. Huxley in one of his groups of Schizognathous forms, the Cecomorphæ, in his celebrated paper, placed the Divers, the Auks, the Gulls, and the Petrels in a group by themselves, and of the Procellaridæ says that they "are aberrant forms, inclining towards the Cormorants and Pelicans among the Desmognathæ" (*loc. cit.*, p. 458).

Next of importance we find Professor Reinhardt in 1873, touching upon certain anatomical characters of Petrels, Albatrosses, and Puffins, and presenting his classification of the Group, and to his paper the reader is referred, inasmuch as his results are

[1] Conspectus generum avium, 1857, tom ii, pp. 184–206.

[2] Coues, E. Critical Review of the Family Procellariidæ. *Proc. Acad. Nat. Sci. Phila.* pt. 1, (pp. 72–91); pt. 2, (pp. 116-144); pt. 3, (pp. 25–33); pts. 4 and 5 (pp. 134–197). Parts 1 and 2 appeared in 1864, and the remaining parts in 1866.

[3] Eyton, T. C. Osteologia Avium, Lond. 1867, pp. 221–225.

Milne-Edwards, M. Al. Recherches anatomiques et paleontologiques pour servir a l'histoire des oiseaux fossils de la France. Paris, 1867–68.

Huxley, Thos. H. On the Classification of Birds, etc. P. Z. S. 1867, pp. 415–472.

too extensive to present in this connection.[1] That same year likewise saw Garrod's studies of the Petrels appear, and finding them 'holorhinal,' he parted them from the 'schizorhinal' Gulls and related forms exhibiting a similar character.[2]

Other papers and works of minor taxonomic importance continued to be put forth, when in 1882 appeared the very extensive and meritorious work of Forbes dealing with the entire anatomy of many forms of the Tubinares, and a thorough study of their probable affinities.[3]

Forbes divided the Tubinares into two families, the Oceanitidæ and the Procellariidæ, which last was subdivided into the two subfamilies — Diomedeinæ and the Procellariinæ. Osteology of the Petrels and their allies filled a prominent place in this able production, and I shall frequently have occasion in the present brief article to refer to it, especially in instances where its author had skeletons of species which the writer has not been able to secure.

Another classification is seen in that of Dr. Stejneger which was published in the Standard Natural History (Boston) in 1885. The following selected from his scheme will show where he places the Tubinares: —

Subclass IV.	Super-Order III.	Order VI.	Superfam. V.
Eurhipiduræ	{ Euornithes	{ Cecomorphæ	{ Procellaroideæ.

In the Procellaroideæ are arrayed the three families Diomedidæ, Procellariidæ, and the Pelecanoididæ. This writer places in his scheme the Tubinares widely removed from the Steganopodes, which I believe to be a mistake, and a non-appreciation of the morphological characters of the latter group of Birds.

In his great work upon the anatomy and taxonomy of birds, Fürbringer makes the Procellariiformes an 'Intermediate Suborder'

[1] Reinhardt, J. Om Vingens anatomiske Bygning hos Stormfugle-Familien. Viden. Medd. Naturh. For. Kjöbenhaon, 1873, pp. 123–138.

[2] Garrod, A. H. Collected Papers, p. 128.

[3] Forbes, W. A. Report on the Anatomy of the Petrels (*Tubinares*) Collected during the Voyage of H. M. S. Challenger. (Zool. Chall. Exp. vol. iv, pt. xi, pp. 1–64. Pls. i–vii (1882).)

["This contribution will be found a most valuable addition to the literature on this remarkable order of pelagic birds." John Murray.]

between his Orders Pelargonithes and Charadriornithes. He considers the Procellariiformes to contain the Procellariæ or Tubinares to which group he gives the name of 'Gens.' The Gens Procellariæ according to him contains but the single family — Procellariidæ. Above the Procellariiformes in the Order Pelargornithes we find the Gens Steganopodes.

In 1890 Mr. H. Seebohm in his "Classification of Birds,"— the "alternative scheme" makes an Order of the Tubinares, placing them in his subclass Ciconiiformes, between the Steganopodes and Impennes. Thus his *third* subclass of birds is arranged as follows: —

Subclass.	Order.	Suborder.
3. Ciconiiformes.	Psittaci.	14. Psittaci.
	Raptores.	15. Striges.
		16. Accipitres.
		17. Serpentarii.
	Pelecano-Herodiones	18. Plataleæ.
		19. Herodiones.
		20. Steganopodes.
	Tubinares.	21. Tubinares.
	Impennes.	22. Impennes.

Professor Hans Gadow regards the Tubinares much in the same light as they are by Fürbringer, placing them as an Order Procellariiformes, (9), between the orders Spheniscifórmes (8) and Ardeiformes (10), the first suborder of the latter being the Steganopodes.[1]

The 'Procellariiformes' constitute Order XV of Dr. Sharpe's classification, and it is subdivided into a suborder — Tubinares, which latter is made to contain the three Families: (1) Diomedeidæ, (2) Procellariidæ, and (3) Pelecanoidæ. Of this author's scheme, Order XIV contains the Spheniscifórmes, and Order XVI, the Alciformes.[2] This authority likewise widely separates the Tubinares and the Steganopodes, the last being included in his Order XXIII or the Pelecaniformes (*loc. cit.* p. 76). In

[1] On the Classification of Birds, P. Z. S. 1892, pp. 229–256. [An able and useful paper.]

[2] Sharpe, R. Bowdler. A Review of the Recent Attempts to Classify Birds. Budapest 1891, pp. 71, 72.

1899 Dr. Sharpe changed this arrangement entirely as will be seen by the following scheme which represents I believe his latest opinions upon this subject.[1] He now places the Procellariiformes between the Sphenisciformes and the Alciformes.

Order (XII).	Family.	Subfamily.	Genera.	No. of Species.
Procellariiformes.	I Procellariidæ.	I Procellariinæ.	Procellaria.	2
			Halocyptena.	1
			Oceanodroma.	13
		II Oceanitinæ.	Oceanites.	2
			Garrodia.	1
			Pelagodroma.	1
			Pealea.	1
			Fregetta.	4
	II Puffinidæ.	I Puffininæ.	Puffinus.	24
			Priofinus.	1
			Thalassœca.	1
			Priocella.	1
			Majaqueres.	2
			Œstrelata.	31
			Pagodroma.	1
			Bulweria.	2
		II Fulmarinæ.	Ossifraga.	1
			Fulmarus.	4
			Daption.	1
			Halobæna.	1
			Prion.	4
	III Pelecanoididæ.		Pelecanoides.	3
	IV Diomedeidæ.		Diomedea.	10
			Thalassogeron.	6
			Phœbetria.	1

This scheme does not enumerate the fossil or subfossil forms given by Dr. Sharpe in the *Hand-List*, of which not a few have been discovered and described. There are about 120 species of Tubinares known to science, and this scheme is very useful in exhibiting at a glance their distribution into genera.

[1] Hand-List of Birds. Vol. I, pp. 120–129. Lond. 1899.

Cope essentially agrees with Stejneger as given above, with the exception that the Superfamilies of the latter are equal to the families of the former. Thus Cope makes the Cecomorphæ contain the families Colymbidæ, Heliornithidæ, Alcidæ, Laridæ, and Procellariidæ.[1]

The writer of the present memoir added his own studies to the literature of this subject in a paper published in 1889, which appeared in the Proceedings of the United States National Museum, it being, in its aim, more descriptive of material then in the collections of that institution, rather than an attempt to classify the Tubinares. In that paper the skeleton of *Oceanodroma furcata* is fully described and figured, also the skeletons of *Fulmarus glacialis* and *F. rodgersii*, ten figures being devoted to the bones of the latter species.

A section is also devoted to the "Osteological points wherein *Oceanodroma furcata* and *Fulmarus rodgersii* differ," and this is followed by some notes on the osteology of *Puffinus tenuirostris* and other material. Finally, a very complete account is given of the skeleton of *Diomedea albatrus*, it being illustrated by twelve figures (nat. size), giving the skull (four views), the vomer (two views), the mandible (two figures), the hyoid arches, the sternum (two figures), and the shoulder-girdle.[2] Taken in connection with my examinations of additional material since that paper was published, and a study of the foregoing works of other authors, the present brief memoir aims simply to bring this subject up to date. I have never been able to get the skeletons of a great many species of procellarine birds, a number of which have been described by Forbes in his above cited work, and the student may readily consult these in the volume of his collected scientific Memoirs published by the Zoological Society of London (R. H. Porter). Either wholly or in part, Forbes examined skeletons of *Diomedea albatrus, Thalassogeron culminatus, Phabetria fuliginosa, Ossifraga gigantea, Fulmarus glacialis, F. glacialoides, Dap-*

[1] Cope, E. D. Synopsis of the Families of the Vertebrata. The Amer. Nat. XXIII, Phil. Oct. 1889, p. 849 *et seq.*

[2] Shufeldt, R. W. Observations upon the Osteology of the Orders Tubinares and Steganopodes. Proc. U. S. Nat. Mus., Vol. XI, Washington, 1889, pp. 253–315.

tion capensis, *Oceanodroma leucorhoa*, *Oceanites oceanicus*, and *Pelagodroma marina*. The skeletons of a number of these have also been examined by me, and in addition thereto I have studied complete skeletons of *Puffinus borealis*, *P. major*, *P. griseus* (?), *P. creatopus*, *Oceanodroma furcata* and others. We also both examined a skeleton of *Puffinus obscurus*, and he also a skeleton of *Bulweria columbina*.

Considering the rarity in collections of the skeletons of tubinarine birds, the ground is pretty well covered by our united examinations, though it is highly desirable that many or all of the others be in time anatomically examined and compared.

II. Some General Notes on the Osteology of the Tubinares.

Bearing in mind what Forbes has recorded in his papers on the *palate* of the Tubinares (*Coll. Sci. Mem.* p. 416), I would say in addition thereto that I find in a skull of *Puffinus borealis* before me, that the inner ends of the maxillo-palatines abut against, on either side, the nearly vertical and lofty scroll of the corresponding palatine. The meeting is quite extensive and coössification appears almost to have taken place at the point of contact. The fenestration in them is hardly evident. We likewise find in the skull of *P. borealis* that the descending plates of the palatines are quite as prominent and well developed as the ascending ones just referred to, while the pterygoidal heads of these bones (palatines) in this shearwater are notably long, and closely applied to each other in the middle line, and to the sphenoidal rostrum. In it, too, the os uncinatum is well seen, being a distinct spine of bone, articulating, upon either side, with the infero-internal border of the lacrymal with its *free* apex pointing downwards and inwards towards the ascending plate of the palatine. In this shearwater the lacrymal is large and pneumatic. It articulates extensively, but does not anchylose with the corresponding frontal and nasal bones, and internally with the broad outer end of the pars plana. Its descending end is bifid and comes in contact with the zygoma, while superiorly its anterior apex is finely pointed, but posteriorly

is blunt and juts backwards and slightly outwards, being found just at the point where the deeply sculptured supra-orbital glandular depression terminates in front. Contrary to Forbes' statement that "well-developed basipterygoid facets are present in all

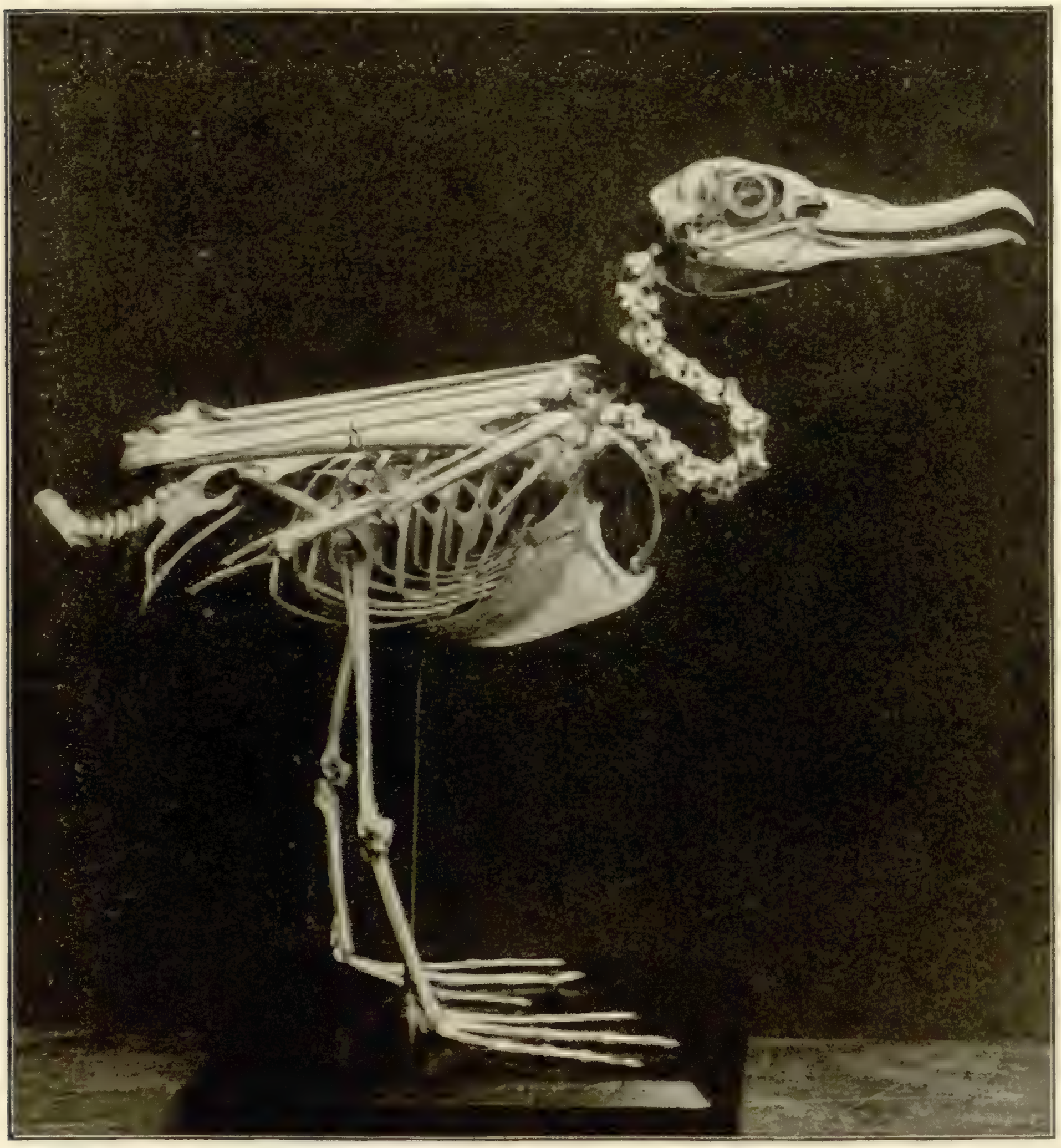


FIG. 1. Right lateral view of the skeleton of a Shearwater (*Puffinus borealis*). Coll. U. S. Nat. Museum, No. 17,772. (From a photograph by Prof. T. W. Smillie, and reduced.)

the forms, except the Diomedinæ, the Oceanitidæ, Procellaria, and Cymochorea," (p. 416), I find them but rudimentary in this specimen of *Puffinus borealis* (No. 17776. Smithsonian Collections), though they are well-developed and functional in a specimen of *Puffinus creatopus* (No. 18,773, Smithn. Coll.). In this last-

named species, too, the maxillo-palatines are well-anterior to the ascending plates of the palatine; moreover, its vomer is notched at its apex, and is not especially curved downward anteriorly. These are three well-marked differences in *Puffinus borealis* and *P. creatopus*, and go to prove, what I have always held, that we can never have too much material before as when comparing the skulls or any other part of the anatomy of birds.

So far as my observation goes I find that Forbes's description of the quadrate bone for the *Tubinares* agrees with what I found in other species of the group not examined or seen by him. But my material does not bear him out so well in his description of the foramen magnum of the Tubinares, and he says that that opening "is more or less reniform, with the major axis transverse, in the small species, whereas in the biggest it is oval, especially in Ossifraga, with the long axis vertical. The moderately sized species are here again intermediate in structure" (p. 417). Of the two shearwaters (Puffinus) before me, birds nearly of a size, and both above the "small-sized species" of the group, it is found to be oval in *Puffinus borealis*, with its major axis vertical, while in *Puffinus creatopus* the foramen magnum is subcircular with the major axis transverse.

The mandible of *Puffinus borealis* has the articular ends somewhat massive, truncated posteriorly, with very deep ramal sides for its hinder half, and very shallow ones anteriorly. Apically it is decurved, and there are lacking recurved angular processes and ramal vacuities. The articular ends are pneumatic, with the facets for the quadrate, of course, the reverse in form to those found on the last-named bone.

The distal elements of the greater cornua of the hyoidean apparatus are much flattened from above downwards, and, as in the Albatrosses, the parts anterior to the basibranchials are not performed in bone. The first basibranchial is subcircular in form, and anchyloses with a short urohyal or second basibranchial (*Puffinus*).

The sclerotic plates in an eye of *P. borealis* are small, and somewhat numerous; they are disposed as we usually find them among birds.

Axial Skeleton: — In the skeleton of *Puffinus borealis* at hand,

I find twenty-one free vertebræ between the skull and sacrum. Of these the thirteenth, fourteenth and fifteenth support a free pair of ribs; they being quite rudimentary upon the first two, but are long and slender on the fifteenth vertebra, and are without unciform appendages. The following *six* vertebræ have ribs that connect with the sternum by costal hæmapophysis. There is also a pair of sacral or pelvic ribs, but their hæmapophyses fail to reach the sternum, and their lower ends make extensive articulation with the last pair of true costal ribs, at some distance above the costal border of the sternum. The pelvis very much resembles the pelvis of Rodger's Fulmar figured by me in the Proceedings of the U. S. National Museum (cited above), and there are eight free caudal vertebræ plus a somewhat elongated pygostyle.

The costal border of the sternum is characteristically wide from side to side, and the pits between the six facettes, unmarked by pneumatic openings, are very shallow. The sternums of these shearwaters agree in their general characters with those of the fulmars.

In *P. borealis* the xiphoidal extremity is doubly notched upon either side of the sternal keel, and the form of the bone is there symmetrical. This is not the case with the xiphoidal extremity of the sternum of my specimen of *Puffinus creatopus*. In it, not only is the left side of the bone somewhat *longer* than the right, but instead of showing the two usual notches of the right, it has three, which appears to have been caused by a bifurcation of the inner xiphoidal process. These inner xiphoidal processes in *P. obscurus* are wonderfully slender.

The shoulder-girdle is much like that of *Daption capensis*, and in Figure 1 I present those parts in that species articulated *in situ* with the sternum. This figure originally illustrated a paper of mine which appeared in the Proceedings of the U. S. National Museum for 1887 (fig. 1, v. X. p. 379), where the skull is likewise described in connection with other observations upon the osteology of the Tubinares, and these should be read in connection with the present memoir.

Returning to the shearwaters, I may say that the arrangement of the bones of the shoulder-girdle in some of them is as we find

it in Daption, and this is the case with *Puffinus obscurus*. The sternum of the former, however, is non-pneumatic, a condition not found in *Puffinus*.

Forbes in his work presents a careful and somewhat lengthy description of the Pectoral arch in general for the *Tubinares*, and it agrees very closely with my own observations upon that bone. I have at present nothing to add to it.

In a specimen of *Puffinus borealis* I find the humerus to measure in length 135 millimetres. The bone is non-pneumatic, and is

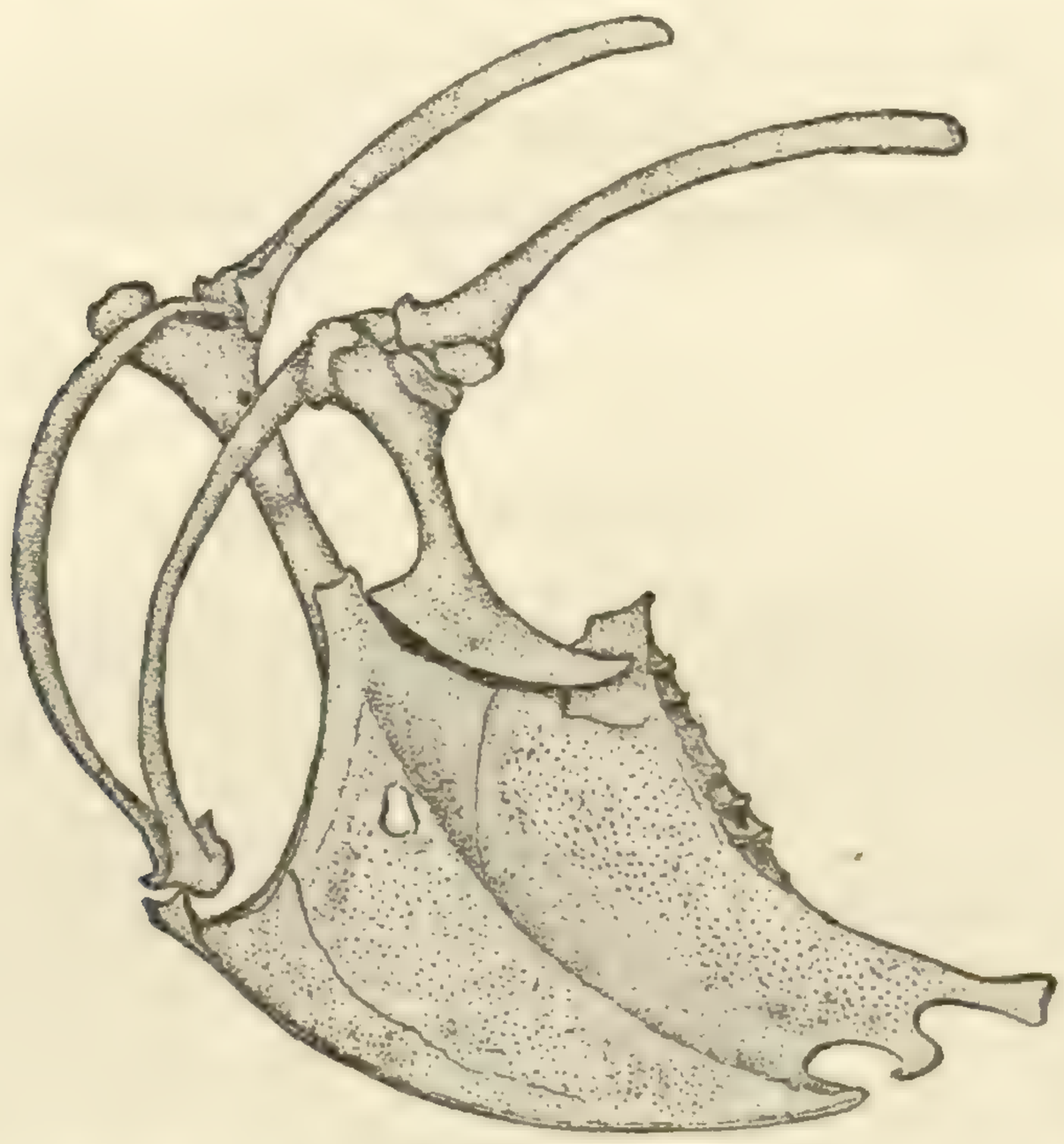


FIG. 1.— Anterior oblique view of the sternum of *Daption capensis*, with the shoulder girdle *in situ*. (Drawn by the author from a specimen in his own collection).

remarkable especially for the prominence of its jutting, papilliform ulnar crest, and conspicuous triangular radial crest. Its shaft is quite straight, and at its distal end, proximal, to the external condyle, we find a strongly developed epicondylar process. Attached to this by ligament is an ossicle of some considerable size, being 14 millimetres long, and of an L-form, with the short arm of the L bent to an obtuse angle. A rather deep, well-defined fossa exists immediately above the oblique tubercle, while the olecranon fossa on the opposite side of the bone is decidedly shallow. "In the Oceanitidæ the humerus is conspicuously a stouter and shorter bone, with its shaft evidently curved instead

of being almost straight [as it is in *Puffinus*]. The epicondylar process projects much less forwards, and is continued down by an elevated ridge to the surface of the condyle itself." (Forbes, p. 422).

Both radius and ulna in Puffinus are comparatively very slender bones, the former, measuring 125 mm., is straight, and presents a well-marked tendinal groove at its disto-superior aspect, over the carpal enlargement. The ulna is likewise a very straight bone in the shearwaters, with the elevations for the quill-butts of the secondary remiges absent from the shaft. Its ends are but very slightly enlarged, as they are in some birds.

The skeleton of the hand has a length almost equaling the length of the radius. The terminal finger-points are long, slender, and pointed distally. Claws are absent. The proximal phalanx of index digit is very long and narrow; its blade not being fenestrated as in the Laridæ. Large and small shafts of the carpo-metacarpus are rather close together and markedly straight. Above its proximal end is a spindle-shaped, free ossicle of some considerable size. Possibly it occurs in the tendon of the tensor patagii longus close to its insertional extremity, but it exhibits no articular facette for the wrist, as does the os prominens of the Owls and others.

The small phalanx of the medius digit is notably free, and develops a tendinal tubercle upon its posterior border. Forbes describes the pectoral limb as it exists in the Oceanitidæ, in Adamastor, in Majaqueus, and in Ossifraga of the Procellariinæ, and compares the same as the skeleton of this limb is found in the Diomedeinæ (*loc. cit.* pp. 422, 423).

Puffinus borealis has a femur that in length hardly equals half that of the tibio-tarsus; it is somewhat antero-posteriorly arched, the convexity being along the anterior border. Its upper end is also antero-posteriorly flattened, with the trochanterian crest about absent, and the pit for the ligamentum teres much scooped out. A small free patella exists. In the tibio-tarsus the striking feature is the enormous development of its procnemial crest with a corresponding sub-suppression of the ectocnemial one. This is even still more marked in *Puffinus creatopus*, where upon the posterior aspect of the common prominence, a well-marked, transverse groove exists, apparently for the accommodation of the

lower margin of the patella. The remaining characters of the balance of the pelvic limb of Puffinus have already been correctly described by Forbes, and consequently it will not be necessary to reproduce his description in this place. He has also compared those characters with those found in various other representatives of this group of birds including Diomedea, Pelecanoides, the Oceanitidæ, and the Petrels. (*loc. cit.*, pp. 424, 425.)

In examining the skeleton in the Oceanitidæ I found among other things that they lack in the skull the basipterygoid processes, and that in them the uncinate bones, found in the skulls of other Tubinares are also absent. The posterior margin of the xiphoidal extremity of the sternum, is usually quite entire; and they have but twenty-one cervico-dorsal vertebræ. These birds also possess, in contradistinction to the Procellariidæ, short and stout humeri, a character which is also seen in the long bones of the fore-arm.

III. On the Taxonomy and Affinities of the Tubinares.

There is a combination of a few marked osteological characters which will serve to distinguish any member of the present suborder from any other existing avian group. The Tubinares all have their skulls characterized by the presence of conspicuous supra-orbital glandular depressions, which are large and generally deeply sculpt.

They are likewise all holorhinal, as well as schizognathous birds, wherein the vomer is usually of considerable size, being more or less broad, pointed anteriorly, and often depressed and arched antero-posteriorly. Combined with these characters we find that in them the hallux of pes to be either absent or else rudimentary in that it is reduced to a single joint. Not more than twenty-three cervico-dorsal vertebræ, nor less than twenty-one are seen to exist. The sternum is short and broad, with its posterior border either entire, or regularly 4-notched, or of an asymmetrical pattern, or even jagged. The patella, when present, is free and small, articulating high up on the posterior aspect of the much-produced procnemial crest of the tibio-tarsus. The sternal extremity of a coracoid is of remarkable width, being nearly as wide there as the bone is long from summit to midpoint

of base. The superior mandible of the skull is conspicuously decurved apically, and very sharp-pointed; symphysis of mandible also more or less decurved, and the articular ends of this bone, truncated posteriorly.

When the skeleton of any bird has associated in it all the osteological characters here enumerated, they are sufficient to indicate that the species belongs to the suborder Tubinares. These characters are thoroughly diagnostic, and typical tubinarine forms possess them in the avifauna in any part of the world.

I am of the opinion that the natural classification of the Tubinares is as follows: —

Suborder.	Families.	Subfamilies.
Tubinares.	1. Procellariidæ.	1. Procellariinæ.
		2. Oceanitinæ.
	2. Puffinidæ.	3. Puffininæ.
		4. Fulmarinæ.
	3. Pelecanoididæ.	
	4. Diomedeidæ.	

This arrangement does not include the extinct forms of this suborder, but nevertheless the characters presented on the part of these have been taken into consideration in connection with taxonomical affinities.

When Mr. Forbes came to sum up his conclusions in regard to this group of birds, at the close of his extensive paper, cited above, he said that L'Herminier, A. Milne-Edwards, and Huxley have all, in describing various points in the osteology of the Tubinares, pointed out similarities of various kinds between their osseous structure and that of various forms of Steganopodes, though they still kept them close to the Laridæ. Eyton, on the other hand, places the various petrels he describes in the family 'Pelecanidæ,' and gulls forming a separate family by themselves."

"But no one will be prepared, I think, to dispute that the Steganopodes are allied to the Herodiones, including under that name the Storks and Herons, with Scopus only."

"Thus, on osteological grounds alone, there is sufficient ground for placing the Tubinares in the vicinity of the Steganopodes and Herodines. And, in fact, neglecting the desmognathous structure of the palate — the taxonomic value of which, *per se*, is becoming

more and more dubious as our knowledge of the structure of birds increases — there is little in the character assigned to the groups Pelargomorphæ and Dysporomorphæ by Professor Huxley that is not applicable to the general Petrel type." (*loc. cit.* p. 434.)

In this connection it is interesting to observe that the Tubinares possess, in common with the Cathartidæ, the Steganopodes, and the Ciconiidæ, a deep-keeled, broad and well-developed sternum; external osseous nares holorhinal; articular ends of mandible posteriorly truncated; an evident tendency of the palatine bones to unite with each other for their posterior moieties; powerfully developed clavicles, which are strongly curved, — and these osteological characters co-exist with other similarities to be found in other parts of the morphological organizations of the respective groups mentioned.

Structurally, the Cathartidæ are of great interest, and the anatomy of those peculiar terrestrial scavengers must be still better known to us than it is, before we can hope to trace their probable ancestry.

Remotely akin to the Steganopodes, the Falconidæ, or more generally, the Accipitres, also are linked with these more lowly avian groups,— as are also the Ardeidæ, through Scopus.

During the ages past, it is quite evident that hosts of intermediate forms linking these families and groups have perished and become extinct. This, taken in connection with the very marked specialization of the remaining genera, goes far towards proving the great antiquity of the entire group, and how vast that extinction of the less specialized forms must have been.

My impression is that perhaps the Tubinares on the one hand see their nearest relatives in the Steganopodes, in fact there can now hardly be any doubt upon this point,— while upon the other hand I am inclined to think that the penguins (Impennes) might be with truth placed next below them, as Fürbringer has done. But such questions as these I will take up more thoroughly later on, when I come, in another connection, to draw up my scheme of classification for the Class *Aves*, and after I have paid further attention to the osteology of other existing groups.

Note: — In closing this Memoir I would say that since it was written there has appeared in the *American Naturalist* my con-

tribution entitled "An Arrangement of the Families and the Higher Groups of Birds (Vol. XXXVIII, Nos. 455–456 Nov–Dec. 1904, pp. 833–857), and, in so far as the taxonomy of the Tubinares is concerned, it sustains what is set forth above; in other words my opinion in the matter remains the same as it was six years ago.

NOTES AND LITERATURE

GENERAL BIOLOGY

Transmutation and Agriculture.—Much of the evidence upon which the evolution theory rests has been derived from the experiments of practical breeders. It is doubtful, however, whether practical workers have ever greatly profited by the incorporation of the results of their experience into general theories of evolution. The present volume [1] seems to be intended as a general and popular review of the evidence which cultivated plants afford the student of the origin of species, rather than as a guide or handbook for those engaged in plant breeding. Naturally many facts of interest to the breeder are to be found in the discussions of the wide range of material treated, but there is no attempt to formulate rules to be followed in any particular class of practical work or to emphasize the significance of any particular theory of evolution for agriculturists. The arrangement of the material under two main divisions, "Minor Species and Mutation," and "The Factors of Variation," might suggest that the author is inclined to attach much significance to the views of de Vries and to the Lamarckian factors. The source of material is not limited to the results obtained by commercial breeders or agricultural experiment stations, but recent experimental work of all kinds and especially that of de Vries and his followers is quite fully treated. In fact, the volume furnishes a rather interesting index to recent literature bearing on the evolution theory. It must be said, however, that it is not easy to grasp the author's own point of view. The work gives somewhat the impression of a series of reviews, and while it is desirable that evolutionary writings should contain less of theory and more of fact than has frequently been the case, a work loses much in interest if it is not written in support of definite theses which are kept constantly and clearly in view. Wanting, as it does, an obvious central purpose, the book is not one of the kind to found a school and it will probably not influence evolutionary literature materially, but it does furnish a very readable presentation of the results of much recent work and will doubtless be of real service to many to whom the more fundamental works are quite inaccessible.

J. A. Harris

[1] Constantin, J. *Le Transformisme appliqué à l'Agriculture.* Paris, Félix Alcan. 1906. 8vo, 300 pp., 105 figs.

Form Analysis.—Slowly but surely the necessity of applying precise mathematical methods to the solution of many biological problems is becoming apparent to workers in both fields. The chief application of mathematical methods has been in the study of variation and heredity, but the problems of leaf form, arrangement of leaves on the stem, and the convolutions of the shells of gastropods may be mentioned as having attracted the attention of mathematical workers. In an address before the American Philosophical Society, Michelson [1] emphasizes the importance of the problems of symmetry and suggests a classification of symmetrical and unsymmetrical forms.

J. A. HARRIS

GEOLOGY

River terraces at Brattleboro, Vt.— Professor Fisher [2] has tested the theory that the river terraces of New England may be accounted for by the behavior of meandering and swinging streams slowly degrading previously aggraded valleys without necessary change in volume and by the control exerted here and there over the lateral swinging of the streams through the discovery of rock ledges, by applying the theory to the explanation of the terraces of the West River near its junction with the Connecticut. It is found that this theory, elaborated by Davis some years ago, is the only one which will adequately account for the features presented in the district under study.

The lateral swinging of rivers by meanders, cut-offs, and short-cuts is considered, and the evidence in favor of a fourth process presented. This latter, called the 'partition process,' results when a sudden withdrawal of the current from banks of erosion is effected, the stream then forming a sand bar which is not continuous with the former banks, and the sand bar grows to an island which parts the stream. Eventually the deeper channel acquires the entire stream, the deserted channel and former island being thus added to the flood plain. The West River, swinging by these various processes, and at

[1] Michelson, A. A. "Form Analysis." *Proc. Amer. Phil. Soc.*, vol. 45, pp. 110–116, 1906.

[2] Terraces of the West River, Brattleboro, Vermont. By E. F. Fisher. Proc. Bost. Soc. Nat. Hist., Vol. 33, pp. 9–42, pls. 1–11. 1906.

the same time slowly degrading its previously aggraded valley, has encountered numerous rock barriers in its down-cutting, these barriers controlling the extent and character of the lateral swinging, and thus determining the variety of terrace pattern described.

The paper is abundantly illustrated by block diagrams, engravings, and by maps and sections based on a careful survey of the region.

D. W. J.

ANTHROPOLOGY

Quaternary Remains of Man in Central Europe. By Hugues Obermaier.[1] The presence of man in central Europe in the Quaternary no longer admits of doubt. The finds of archeological and skeletal human remains dating back to that period, have been numerous and well authenticated. They have, in fact, become so numerous and publications concerning them are so scattered, that a good grasp of the whole subject is at present a matter of difficulty. Under these circumstances, Obermaier's effort to establish "a list of all the quaternary anthropological discoveries, discarding those the antiquity of which is disputable," is much to be commended. This is especially the case when we learn that the author endeavored to form his opinions by visiting the localities where the finds have been made, by personally examining the collections, and by consulting the men who made the discoveries.

The following succession of stages and substages during which man existed in Europe is admitted:

I. *2nd interglacial stage*
   Substages: Chellean (fauna of a hot climate)
   Acheulean (fauna of a hot temperate climate)
   The Micoque phase (fauna of the steppes)

II. *3rd glacial stage*
   Mousterian (fauna of cold climate)

III. *3rd interglacial stage*
   Mousterian (fauna of temperate, then of hot climate)
   Solutrean (fauna of temperate and finally of cold climate)

[1] Les restes humaines quaternaires dans l'Europe centrale. L'Anthropologie, XVI, 1905, pp. 385–410, XVII, 1906, 55–80.

IV. *4th glacial stage, and retreat of the glaciers*
Magdalenian (fauna of cold climate)
Last quaternary industries

The finds that M. Obermaier considers as indubitably of quaternary age can be conveniently arranged into a table. They are as follows:

Country	Locality	Discovered or first reported by	Nature of the Find	Period from which it dates
Moravia	Cave Špika	Maška	Paleoliths. A fragment of human lower jaw	Mousterian (fauna of cold climate); upper layers more recent
	Předmost	Wankel, Maška, Kříž	Over 25,000 paleoliths. Objects from ivory, bone, wood. Human bones	Corresponding to later Solutrean
	Brno (Brünn)	Makovský	Human skeleton. Objects of stone, bone, ivory	Same as preceding
Croatia	Cave Krapina	Gorjanovič-Kramberger	Human bones. Stone objects	Mousterian (with fauna of hot climate)
Austria	Willendorf	Fischer, Woldrich	Piece of human femur. Numerous implements of stone. Objects of horn and bone	"Paléolithic supérieur" corresponding to that of Předmost
	Cave Gudenushöhle near Krems	Hacker Woldřich	1300 stone implements, objects of horn and bone, a human tooth	Magdalenian
Germany	Taubach near Weimar	Porti, Nehring	Stone implements. Human tooth	Mousterian (hot)
	Andernach near Coblenz	Schaafhausen	Stone implements. objects of bone, wood. Human teeth and parts of bones	Magdalenian (cold)
Switzerland	Cave at Freudental	Karsten	Implements. Human bones	Magdalenian
	Cave of Kesserloch	Merk, Nuesch, Heierli	Numerous stone implements and objects of bone or wood	Solutrean

Among the 'doubtful,' the author places the skulls of most (Brüx), Podbaba, Canstatt, Egisheim, and Neanderthal.

The whole paper is concise, easily read, and furnished with numerous bibliographical references. It is to be hoped the author will follow up the subject and outline in the near future the really ancient and the doubtful human remains in France, and other parts of Europe.

A. HRDLIČKA

Pagan Races of the Malay Peninsula.[1]—The two handsome volumes of over 1500 pages constitute unquestionably the most important contribution to the knowledge of the less civilized peoples of southeastern Asia. The work, according to the authors (p. VII et seq.) claims to belong to the scope of "descriptive ethnography," but this is rather an unfortunate term because of its redundancy; the text, with the exception of somatological notes, comes wholly under 'ethnology,' as understood in this country. It is "essentially a compilation from many sources, but differs from most books of that kind, first, in being based to a very large extent on materials hitherto unpublished, and accessible only through private channels of information; and secondly, in having been constructed with special knowledge of the subject and in a critical spirit." It is a work of "many facts, but few hypotheses," and should be regarded not solely as a monograph on the tribes dealt with, "but also as a necessary preliminary to a general scientific survey of the races of southern Indo-China and the Malay Peninsula" — which survey is strongly advocated. The objectionable term "pagan," used in the title as a discriminative of races is justified by the opinion that "the point of religion (as between Mohammedan and non-Mohammedan) was perhaps a better dividing line, on account of its definiteness, than the vague, indefinite, and perhaps undefinable, quality of wildness." The bulk of the book was written by Skeat, the attention of Blagden being confined to language.

The contents of the two volumes, besides preface, bibliography, and introduction, are, vol. I: Racial characters and affinities; Notes on diseases; food, stimulants, narcotics; dress; habitations; hunting, trapping, and fishing, barter; weapons and implements; cultivation; arts and crafts; decorative art; social order; dealings with other races; and place and personal names. Vol. II: Birth-customs and beliefs; maturity customs and beliefs; marriage customs and beliefs; burial customs and beliefs; music, songs, and feasts; natural religion and folk-lore; and language. Both volumes are provided with abundant illustrations, nearly all of which are photographs.

The reading of the book reveals a mass of details such as has been brought together in few other works, and which will be of great utility in further studies of the peoples of the Malay Peninsula, as well as that from the mainland further north and the islands to the southward.

Three distinct racial types are recognized, namely the Semang, or

[1] Skeat, W. W., and Chas. O. Blagden. Pagan Races of the Malay Peninsula. 2 vols., 8vo, London (Macmillan & Co.), 1906. 42/net.

Negrito, the Sakai, of suggested Dravidian ancestry, and the Jakun, or aboriginal Malay. They differ principally in head form, physiognomy, and nature of the hair. The Semang are meso- to brachycephalic, with woolly hair, and features approaching, in a number of particulars, the negro; the Sakai are dolichocephalic, with wavy hair and finer features; the Jakun are brachycephalic, with straight hair and with the features of the Malay in general. All are short in stature, but the Semang are the smallest. In color the Semang are chocolate-brown to black, the Sakai and Jakun ranging from brown to yellowish. Both the Sakai and Jakun show numerous instances of admixture with the Negrito.

The chapters on the foods and mode of life of the individual tribes are valuable; but the diseases of the people, their environment, and especially their physiology are far from being treated adequately. The total number of the 'pagan' aboriginies of the Malay Peninsula appears to be no more than 35,000 or 40,000.

For the mass of details concerning the habits, religion, folk-lore and language of the tribes the reader must be referred to the original.

The book as a whole will not be found easy reading. This is partly due to its plan, including several appendices, partly to the many native names, and in some degree to the style of the authors. More tabulation would have been of help. However, the work must be regarded not as a narrative, but more as a reference hand-book of the tribes of the Malay Peninsula, and as such it will be highly appreciated by every student of that region. For this purpose, however, a more copious index, and page references instead of the occasional "will be found in another part of the work," would have been desirable.

The illustrations are not always satisfactory. There are a number of photographs that show but little, and a few (*e. g.* the "Kedah-Raman," "Kedah," superior plane of the Semang skull, the "Semang of Grit," the "Sakai at G. Kerbu," the "Group of Ulu Jelai Sakai") which are wholly useless, being out of focus. It is not easy to see what was the object of the authors or publishers in including these pictures with the many others which are of real value.

A. HRDLIČKA

Growth of Parisian Children.[1]—The paper presents the results of the determinations of height and weight of 4400 children from various

[1] Tables de croissance des enfants Parisiens de I a 16 ans. Par MM. Variot et Chaumet. Bull. & Mém. Soc. d'Anthrop. Paris, Vme Sér., VII, No. 2, pp. 51–65.

Parisian nurseries and schools. The series includes at least 100 subjects of each sex for every year of life, which insures the value of the averages. The study is the first of its nature made in France; Godin's well known observations were made on older individuals.

The results agree in the main with those of measurements of white children in other countries.[1] Up to the end of their eleventh year the girls are shorter than the boys; between their eleventh and twelfth years they pass the boys in this regard, and continue taller until after their fourteenth year, after which they are definitely passed by the boys. In weight the physiological excess of the female children becomes marked even earlier and they exceed the boys from the end of the ninth to a little beyond their fifteeth year.

A comparison of these data with those obtained by Professor C. P. Bowditch on Boston children shows that between the ages of thirteen and sixteen the Parisians slightly exceed the Americans in height. This can very likely be attributed to earlier puberty in the French adolescents.

A. H.

Anthropometric data on the Norwegians.—Messrs. Daae report[2] the results of measurements, by military surgeons, of 3,955 recruits of between 22 and 23 years of age.

The data show that the average stature of the Norwegians of that age is 172.1 cm. The tallest men are in the district of Jarlsberg-Larvik (173.4 cm.), the shortest in the district of Finmarken (168.5 cm.).

The mean arm-spread amounts to 178.2 cm., and is to stature as 103.55 to 100. It is relatively shortest (102.2 to 100) in the Bergenhus-Sud district, peopled by fishermen who all the year around work with oars.

Height sitting was found to average 91.2 cm., bearing a relation to stature as 52.98 to 100. The proportion is smaller (52.46) among the tallest men, and larger (53.61) among those of the shortest stature.

The mean circumference of the chest is 87.3 cm., ranging in the districts from 86.2 to 89.6. The relation it bears to stature is as 51.04 to 100.

A. H.

[1] See the American Naturalist, XXXIII, July, 1899, p. 605 et seq.

[2] Sur la taille, l'envergure, le périmètre thoracique et la hauteur du buste chez les populations de l'intérieur et de cotes de la Norvège. Par M. A. Daae et le Dr. H. Daae. Bull. & Mém. Soc. d'Anthrop. Paris, Vme Sér., VII, No. 3, 1906, pp. 158–164.

The population of Tripoli, according to the latest official data,[1] amounts to 711,242. Among this are 16,670 Jews. The most southern point at which the latter are found is Orfella. They live an extremely miserable life and in places suffer even partial slavery. They do not emigrate because they know not where to go.

A. H.

ZOÖLOGY

Dean's Chimæroid Fishes[2] is one of the most strikingly illustrated works yet issued by the Carnegie Institution. Any adequate summary of its contents is impossible here; all that can be attempted is an enumeration of its contents. For several years Dr. Dean has labored indefatigably in obtaining embryos of this group of rare Selachians. The work is based on the eggs of the Pacific *Chimæra collei*, the eggs of which were obtained from the gravid females and then incubated in floating boxes, but unfortunately these often broke adrift and about 150 eggs have been lost in this way.

After an introductory chapter on methods and the like Dr. Dean first describes the appearance, habits, etc., of the fish and then proceeds to a study of the development. The egg-capsule is beautifully figured and described in detail, this part of the work being made more valuable by figures of the egg-capsules of other chimæroids, both recent and fossil. The egg is fertilized before oviposition and Dr. Dean was fortunate enough to get specimens showing various phases of the process of fusion of the male and female pronuclei. Polyspemy is apparently the usual condition. The segmentation is in general of the usual Selachian discoidal type but is accompanied by a fragmentation of the yolk. A single early stage of gastrulation is described in detail, the striking feature being that the blastopore is not, as in other elasmobranchs, at the edge of the blastoderm but inside its rim, a condition which throws much light on gastrulation in other forms, conclusions which are supported by two other stages.

[1] Méhier de Mathuisieulx, L'Anthropologie, XVII, 1906, Nos. 1–2, pp. 237–239.

[2] Dean, Bashford: Chimæroid Fishes and their development. Carnegie Institution, Publication 32, Washington, 1906, pp. 194, 11 plates.

Of the stages after the closure of the medullary folds the accounts are far less detailed than we could wish and there are many gaps in the organogeny which remain to be filled but which cannot at present be described on account of lack of material. Especially interesting are the figures given of a reconstruction of the skull of a well advanced embryo in which the pterygoquadrate bar is not completely fused with the cranium. Other features of organogeny given are concerned with (1) the integument and dentition in which embryos and larvæ of other chimæroids are considered and the conclusion is reached that the dental plates represent fused denticles. (2) The skeleton which is largely based on the work of Schauinsland. (3) The viscera. There is, even in early stages, no continuous mesentery. A few words are devoted to gut, gills and nephridial structures.

The third section, one of the most valuable of the work, is a discussion of the fossil chimæroids. The existence of Silurian members of the group is more than doubted, but, as shown by the Ptyctodonts, they probably occurred in the Devonian. The definite knowledge of the group began with the lower Jurassic, since which time numerous undoubted chimæroids have occurred, the group attaining its maximum development in the cretaceous. These fossils and the structure and embryology of the existing species are invoked to show that the chimæroids are not a primitive group but are a modified and specialized development from forms more like the normal Selachians. An extensive bibliography closes the volume.

J. S. K.

Development of the Mammalian Lung. Flint (Am. Journ. Anat. 6, 1906) describes in a long paper the development of the lung and associated structures in the pig The anlage is asymmetrical, and its origin, below the level of the gill pouches is an argument against any phylogenetic connection between lungs and gill pouches. The development of the bronchi is followed in detail and many variations noted, the complete series including sixteen on one side and seventeen on the other, a condition rarely occurring. Æby's conclusion that the pulmonary artery differentiates two lung regions of different morphological significance is not supported. The pulmonary veins arise as an outgrowth from the undivided portion of the sinus venosus, the veins to the right and left lungs developing by specialization in the capillary plexus. In the earlier history the division of the respiratory ducts is monopodial in character as in the lower pulmonate vertebrates and it is only in the other stages that dichotomous division, characteristic

of the mammals, sets in. The histogenesis and the development of the lymphatic system are also traced. The early stages were studied by Born reconstruction methods, the later by dissection and by corrosive preparations.

Half Hours with Fishes, Reptiles and Birds[1] is the second in the series of books by C. F. Holder, designed as supplementary readers for children in the grammar grades. The section devoted to birds suffers from the same defects in the arrangement of material that were pointed out in the review of the earlier volume (*American Naturalist*, **40**, *p. 140, 1906*). The part dealing with fishes is full of interesting information vividly presented.

R. H.

Notes.— In the Proceedings of the Indiana Academy of Science for 1905 (1906) Dennis and Petry give an interesting series of photographs of the young of the turkey buzzard showing the changes in the plumage from the tenth to the seventy-fourth day after hatching.

Zeleny (Proc. Acad. Sciences Indiana [for 1905] 1906) describes the regeneration of an antenna-like appendage in the place of an excised eye in the blind crayfish. The new organ has the appearance of a functional tactile organ and the experiment has especial interest in that a functional organ has developed in place of the functionless eye.

Martin describes (Proc. Indiana Acad. Sci. [for 1905] 1906) a handy clamp by which the blades of 'safety razors' may be used for section cutting, thus materially reducing the cost, confusion, etc., of supplying section knives to large classes.

Madison Grant publishes some "Notes on Adirondack Mammals" in the Eighth and Ninth Report of the Forest Fish and Game Commission of New York. The paper, which supplements Dr. Merriam's well known work on the same region, is illustrated with some fine half tones, some taken in the forest, others in the New York Zoological Gardens.

C. W. Johnson has collected all the references to the appearance and distribution of the English garden snail, *Helix hortensis*, in America and is inclined to think (Nautilus, **20**, p. 73, 1906) that it has not been

[1] Half Hours with Fishes, Reptiles and Birds. By Charles Frederick Holder. N. Y. American Book Company. pp. 255. Illustrated.

introduced by man within comparatively recent years nor by the "vikings" but is a much older inhabitant of this continent.

Lönnberg (Arkiv för Zoologi, **3,** 1906) discusses the systematic position of the extinct Irish Elk. This is usually closely associated with the common fallow deer. Lönnberg thinks that this association rests almost exclusively upon the somewhat similar palmated antlers but that in other and more important features there is more affinity with the reindeer than with any other cervicorn, although it presents considerable specialization in its own line.

Froriep gives (Verhandl. Anatom. Gesellschaft, XX, 1906) a detailed comparison of the eyes of vertebrates and tunicates and concludes that both are derivable from a common ancestral condition which is closer to the optic pit of the vertebrate than to the eye of the ascidian larva. Two weeks later comes the Anatomischer Anzeiger (xxix, p. 526 Nov. 24, 1906) in which Metcalf discusses the relation of the vertebrate eye to that of Salpa suggested by Redikorzew, and holds that the views of the latter are untenable but he says "It may not unlikely be true that the condition with a single anterior enlargement of the central nerve tube is ancestral (cf. Amphioxus and the tunicate tadpole)."

BOTANY

The Journals: — *The American Botanist,* September: — Saunders, "Under Sierra Pines"; Bailey, "The Leaf Alert or Drowsy"; Dobbin, "A Word Concerning Trees"; Blanchard, "A New Dewberry."

The Bryologist, September:— Haynes, "Some Characteristics of *Lophozia inflata* and *Cephalozia fluitans*"; Evans, "*Lepidozia sylvatica*"; Best, "*Ptychomitrium leibergii*"; Howe, "Some Additions to the Flora of Middlesex County, Mass."; Nayler, "Microscopical Technique"; Merrill, "Lichen Notes no. 4, — A Study of *Umbilicaria vellea* and *U. spadochroa.*"

The Botanical Gazette, August:— Ganong, "The Nascent Forest of the Miscou Beach Plain"; Shreve, "The Development and Anatomy of Sarracenia"; Osterhout, "Physiologically Balanced Solutions for Plants"; Hasselbring, "The Appressoria of the Anthracnoses"; Frye,

"*Nereocystis luetkeana*"; Greenman, "Two New Species from Northeastern America."

The Botanical Gazette, September:— Blakeslee, "Differentiation of Sex in Thallus Gametophyte and Sporophyte"; Shantz, "A Study of the Vegetation of the Mesa Region East of Pike's Peak: The Bouteloua Formation — II"; Kauffman, "Cortinarius as a Mycorhiza-producing Fungus"; Smith and Smith, "A New Fungus of Economic Importance" [*Pythiacystis citriophthora*,— forming a transition from Pythium to Phytophthora].

The Botanical Gazette, October:— Atkinson, "The Development of *Agaricus campestris*"; Crocker, "Rôle of Seed Coats in Delayed Germination"; J. D. Smith, "Undescribed Plants from Guatemala and Other Central American Republics"; C. O. Smith, "A Bacterial Disease of Oleander."

Bulletin of the Torrey Botanical Club, August:— Arthur and Kern, "North American Species of Peridermium"; MacKenzie, "Notes on Carex — I"; Abrams, "Two New Southwestern Species of Pentstemon."

Bulletin of the Torrey Botanical Club, September:— Eaton, "Pteridophytes Observed during three Excursions into Southern Florida"; Mathewson, "The Behavior of the Pollen-tube in *Houstonia cærulea*"; House, " Studies in the North American Convolvulaceæ — II. The Genus Operculina."

Bulletin of the Southern California Academy of Sciences, June:— Hasse, "Contributions to the Lichen Flora of Southern California"; Parish, "Additions and Corrections," and "A Preliminary Synopsis of the Southern California Cyperaceæ — XII."

Journal of Mycology, July:— Kellerman, "Mycological Expedition to Guatemala"; Charles, "Occurrence of Lasiodiplodia on *Theobroma cacao* and *Mangifera indica*"; Hedgcock and Spaulding, " A New Method of Mounting Fungi Grown in Cultures for the Herbarium"; Peck, "A New Species of Galera"; Arthur, "Reasons for Desiring a Better Classification of the Uredinales"; Morgan, "North American Species of Lepiota; [I.] Descriptive Synopses of Morgan's North American Species of Marasiums"; and "Synopsis to North American Species of Heliomyces"; Garrett, "Field Notes on the Uredineæ"; Kellerman, "Notes from Mycological Literature — XX."

Journal of the New York Botanical Garden, September:— Murrill, "Further Remarks on a Serious Chestnut Disease"; Rusby, "Obser-

vations in Economic Botany Made at Oscoda, Mich." Gager, "Symbiosis in *Gunnera manicata*."

Journal of the New York Botanical Garden, October:— Murrill, "A Summer in Europe: Some Foreign Botanists and Botanical Institutions."

The Plant World, August:— Fink, "The Gynæcocentric Theory and the Sexes in Plants"; Rusby, "An Historical Sketch of the Development of Botany in New York City" (*concluded*); Cook, "Tropical Epiphytes."

The Plant World, September:— Shreve, "The Hope Botanical Gardens"; Gager, "Outline Study of Seeds and Seedlings"; Robinson, "The Filmy Ferns."

Rhodora, August:— Lamson-Scribner, "The Genus Sphenopholis"; Blanchard, "Some Maine Rubi. The Blackberries of the Kennebunks and Wells — I"; Collins, "Notes on Algæ — VIII"; Fernald, "Some New or Little Known Cyperaceæ of Eastern North America."

Rhodora, September:— Blanchard, "Some Maine Rubi. The Blackberries of the Kennebunks and Wells — II"; Fernald, "Some New or Little Known Cyperaceæ of Eastern North America" (*continued*); Knight, "A New Variety of *Carex trisperma*"; Hill, "The Perianth of *Rynchospora capillacea* var. *leviseta*"; Knight, "*Habenaria macrophylla* in Maine."

Rhodora, October:— Collins, "Acrochætium and Chantransia in North America"; Robinson, 'The Nomenclature of the New England Lauraceæ"; Fernald, "Some New or Little Known Cyperaceæ of Eastern North America"; Robinson, "*Filipendula rubra*, a new Binomial."

The fourth annual volume of the *International Catalogue of Scientific Literature, M, Botany*, is dated in July, 1906, and forms an octavo of nearly 1000 pages.

Torreya, September:— Gager, "Tuber-Formation in *Solanum tuberosum* in Daylight," Murrill, "A New Chestnut Disease" [*Diaporthe parasitica*]; Bailey, "A Newly Introduced Plant in Rhode Island"; Hollick, "An Addition to the Flora of Block Island"; Robbins, "Tubular Ray-Flowers in *Gaillardia aristata*"; Wilson, "Mycological Notes from Indiana"; Harper, "A hitherto Unnoticed Relation Between *Viola pedata* and *Iris verna*"; Bruckman, "Fasciations in Arisæma, Rudbeckia, and Viola."

Torreya, October:—Harper, "Midwinter Observations in Southeastern Mississippi and Eastern Louisiana"; Dowell, "Observations on the Occurrence of Boott's Fern"; Farwell; "Note on the Identity of *Trillium obovatum* Pursh"; MacKenzie, "*Lespedega simulata* in New Jersey"; Gager, "Further Note on the Formation of Aërial Tubers in Solanum."

Vol. 7, part 4, of the current botanical series of *Transactions of the Linnean Society of London* is devoted to an account of Sutcliffia, representing a new type of Medulloseæ from the lower Coal Measures, by Scott.

Zoe, September:—Brandegee, "Plants of California," "New Species of Mexican Plants Collected by Dr. C. A. Purpus," and "Plants of Sinaloa."

The following papers of botanical interest occur in the recently issued second volume of *Proceedings of the American Breeders' Association*:—Shamel, "Tobacco Breeding"; Montgomery, "The Corn Plant as Affected by Rate of Planting"; Lyon, "Some Correlated Characters in Wheat and Their Transmission"; Ten Eyck, "Plant Adaptation"; Freeman, "The Use of the Seed Plant in the Prevention of Diseases in Wheat"; Ward, "Economic Value of Plant Breeding"; Westgate, "A Method of Breeding a Strain of Alfalfa from a Single Individual"; Webber, "Correlation of Characters in Plant Breeding"; Keyser, "Variation in Wheat Hybrids"; Funk, "Practical Corn Breeding on a Large Scale"; Hopkins, "Breeding Timothy"; Emerson, "Laboratory Work in Plant Breeding"; Gauss, "Breeding Drought-Resistant Crops"; Bessey, "Crop Improvement by Utilizing Wild Species"; Zavitz, "Breeding Cereals"; Hansen, "Breeding Hardy Raspberries for the Northwest"; Carleton, "Fundamental Requirements for Grain Breeding"; Hartley, "Value of Corn Pollen from Suckers *vs.* from Main Stalks"; Stockdale, "Improvement of Sugar Cane by Selection and Hybridization"; Hays, "American Work in Breeding Plants and Animals"; Hansen, "Methods of Breeding Hardy Fruits"; Williams, "Methods and Results of Hybridizing Fruits"; Keyser, "Methods in Wheat Breeding"; Beach, "Grape Breeding"; Fruwirth, "Enclosing Single Plants, and its Effect on a Large Number of Important Agricultural Species"; Camp, "Breeding Grapes"; Patten, "Results from Work in Breeding Hardy Fruits."

(*No. 481 was issued January 8, 1907*)

Young man, aged 26, excellent collector and setter of Lepidoptera, can also make bird skins, desires a place as assistant with museum, professional naturalist or private collector. Is prepared to travel abroad. Write C., Box 4373 Willings, 125 Strand, London, W. C. England.

ARE YOU INTERESTED IN PHOTOGRAPHS OF BIRD-LIFE?

Then you should send One Dollar for a year's subscription to

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

Edited by J. GRINNELL.

"The photographic illustrations alone are worth the price of subscription."
—*The Critic.*

Contributors in the past have included—
Robert Ridgway, Dr. A. K. Fisher, Vernon Bailey, Maj. Mearns, Florence Merriam Bailey, Joseph Grinnell, W. K. Fisher, Louis A. Fuertes, E. W. Nelson, F. S. Daggett, Joseph Mailliard, and other well known ornithologists.

SUBSCRIPTION, $1.00. SAMPLE COPY, 20 CENTS.

H. T. CLIFTON, BUS MGR., P. O. BOX 404, PASADENA, CALIF.

School Science and Mathematics

A MONTHLY JOURNAL FOR SCIENCE AND MATHEMATICS TEACHERS

It is the only magazine of its kind published in the English language. It gives new ideas and methods of scientific and mathematical instructions—and acts as a clearing house for all that is advanced and good in scientific and mathematics instruction. It is the official organ of many science and mathematics teachers' associations.

EIGHT DEPARTMENTS—Botany, Chemistry, Earth Science, Mathematics, Metrology, Problems, Physics and Zoology.

"Almost a necessiry." Bruce Fink, Professor of Botany, Iowa College.
"The practical hints are valuable to teachers." H. C. Cooper, Ass't Professor of Chemistry, Syracuse University.
"I value the magazine highly. It is most excellently conducted." John S. Collins, Ass't Supt. of Schools, St. Louis, Mo.
"The Problem Department is very interesting and adds greatly to the value of the magazine." H. E. Cobb, Professor of Mathematics, Lewis Institute, Chicago.
"I do not intend to dispense with the magazine as long as it continues as helpful as it has proven to be in the past." Etta M. Bardwell, Biology Department, High School, Ottumwa, Ia.
"I feel that 'School Science' should be in every high school. I shall be glad to further the interests of the journal whenever it is possible." W. M. Cobleigh, Department of Physics, Montana State college of Agriculture.
"I wish to express my appreciation of your magazine. It is a most helpful and inspiring pastime to read the sensible, to-the-point articles it contains." W. T. Heilman, Instructor in Mathematics, Central High School, Columbus, O.
"Your paper is not in the usual class of school papers. I wish to help along the kind of work you are doing." Geo. P. Bristol, Director Summer Session, Cornell University.

$2.00 PER YEAR. 25 CENTS PER COPY.

SCHOOL SCIENCE AND MATHEMATICS

440 KENWOOD TERRACE, CHICAGO, ILL.

SCHOOL SCIENCE AND MATHEMATICS will be sent for THREE MONTHS for 50 cents to a new subscriber mentioning The American Naturalist.

Bird-Lore

A BI-MONTHLY MAGAZINE FOR BIRD-LOVERS

EDITED BY FRANK M. CHAPMAN

Official Organ of the Audubon Societies

Audubon Department

Edited by MABEL OSGOOD WRIGHT and WILLIAM DUTCHER

Bird-Lore's Motto: *A Bird in the Bush is Worth Two in the Hand*

If you are interested in birds, you will be interested in BIRD-LORE. Each number contains two or more colored plates, accurately figuring the male and female of several species of birds, together with numerous photographs of birds from life. The general articles and notes from field and study are interesting, stimulating and helpful; the book reviews, editorials, and Audubon Department informing, and, in short, the magazine is indispensable to every one who would keep abreast of present-day labors in the field of bird study and bird protection.

Reduced facsimile of the reproduction of Ernest Thompson Seton's drawing of the Bob-white. Presented to every subscriber to Vol. VIII, 1906, of BIRD LORE. The original, printed on heavy plate paper, suitable for framing, is nearly life size.

Each number of BIRD-LORE contains a four-page teachers' leaflet, illustrated with a colored plate. All teachers subscribing to BIRD-LORE will receive, free of charge, two extra copies of each of these leaflets, two colored plates, and six facsimile outlines for coloring, for use in their classes.

Subscription Blank

THE MACMILLAN COMPANY

66 Fifth Avenue, New York City, or Box 655, Harrisburg, Pa.

Please find enclosed One Dollar, for which mail me BIRD-LORE, Vol. VIII, 1906.

Name .....

Address .....

$1.00 a Year; 20 Cents a Copy.

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS — HERBERT S. JENNINGS — THOMAS H. MORGAN
WILLIAM E. CASTLE — FRANK R. LILLIE — GEORGE H. PARKER
EDWIN G. CONKLIN — JACQUES LOEB — CHARLES O. WHITMAN
CHARLES B. DAVENPORT — ROSS G. HARRISON, *Man. Ed.* — EDMUND B. WILSON

Volume I, containing 616 pages, 5 plates, and 478 text illustrations, and Volume II, containing 630 pages, 12 plates, and 228 text illustrations, are now complete.

CONTENTS OF VOLUME III

No. 1 — February, 1906

Studies on Chromosomes. III. The Sexual Differences of the Chromosome-Groups in Hemiptera, with Some Considerations of the Determination of Sex. . . . . **Edmund B. Wilson**

An Examination of the Effects of Mechanical Shocks and Vibrations Upon the Rate of Development of Fertilized Eggs . . . . **David D. Whitney**

Morphology of the Parthenogenetic Development of Amphitrite. **John W. Scott**

The Development of Fundulus Heteroclitus in Solutions of Lithium Chlorid, with Appendix on its Development in Fresh Water. **Charles R. Stockard**

Partial Regeneration of the Sperm-Receptacle in Crayfish. . **E. A. Andrews**

Experimental Study of Light as a Factor in the Regeneration of Hydroids. . . . . **A. J. Goldfarb**

No. 2 — July, 1906

Experiments on the Behavior of Tubicolous Annelids . . . **C. W. Hargitt**

Inheritance of Dichromatism in Lina and Gastroidea . **Isabel McCracken**

The Elementary Phenomena of Embryonic Development in Chætopterus. . . . . **Frank R. Lillie**

The Regeneration of Grafted Pieces in Planarians . . . **Lilian V. Morgan**

No. 3 — September, 1906

Locomotion of Amoebae and Allied Forms. . . . . **Oris F. Dellinger**

The Influence of Light and Heat on the Movement of the Chromatophore Pigment, especially in Lizards. . . . . **George H. Parker**

Light Reactions in Lower Organisms. I. Stentor Coeruleus. . **S. O. Mast**

Some Reactions of Caterpillars and Moths . . . . . **Alfred G. Mayer and Caroline G. Soule**

Modifiability in Behavior. II. Factors Determining Direction and Character of Movement in the Earthworms. . . . . **H. S. Jennings**

A Study of the Spermatogenesis of Coptocycla Aurichalcea and Coptocycla Guttata, with Especial Reference to the Problem of Sex Determination. . . . . **W. N. Nowlin**

No. 4 — In Press

The Influence of Gases and Temperature on the Cardiac and Respiratory Movements of the Grasshopper. . . . . **E. A. Walling**

The Physiology of Regeneration. . . . . **T. H. Morgan**

Torsion and Other Transitional Phenomena in the Regeneration of the Cheliped of the Lobster (Homarus Americanus). . . . . **Victor E. Emmel**

The Relation Between Functional Regulation and Form Regulation. **C. M. Child**

Studies on the Development of the Starfish Egg. . . . . **D. H. Tennent and M. J. Hogue**

Hydranth Formation and Polarity in Tubularia. . . . . **T. H. Morgan**

PRICE OF SUBSCRIPTION PER VOLUME — *Payable in Advance*

To subscribers in the United States, Canada, and Mexico,	$5.00
To subscribers in other Countries, ...	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount.

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to THE JOURNAL OF EXPERIMENTAL ZOÖLOGY. Address all communications to

THE JOURNAL OF EXPERIMENTAL ZOOLOGY,
N. E. COR. WOLFE AND MONUMENT STREETS,
BALTIMORE, MD., U. S. A

PLEASE MENTION THIS JOURNAL.

FROM $175 TO $6

If you were to subscribe for the English quarterlies, magazines, reviews, and literary, political, and scientific journals from which THE LIVING AGE takes its materials, they would cost more than $175. You would also waste a good deal of time in sifting out the important from the trivial, and determining what was really worth your reading.

THE LIVING AGE practises this art of skipping for you, and gives you, for $6, in a single weekly magazine, light and easy to hold, the best essays, the best fiction, the best poetry, and all the most timely and important articles from this long list of periodicals, reprinted without abridgment.

Six Dollars is not a large sum to pay for 3,300 pages of the best contemporary reading, covering all subjects of human interest, and embodying the freshest thought in literature, art, international affairs, and current discussion.

THE LIVING AGE presents each year twice as much material as is contained in one of the four-dollar monthly magazines. As it has the whole field of English periodical literature to select from, it is able to present a wider range of subjects, treated by a more brilliant list of writers, than any single magazine, English or American.

But you can buy a magazine for less money? Certainly. There are more magazines than one can easily count which may be had for one dollar a year each.

But there are magazines and magazines. THE LIVING AGE presupposes intelligence and an alert interest in what is going on. To people of that sort it has ministered successfully for more than sixty years. It holds its field alone, and it was never more nearly indispensable than now.

Subscribers for 1907 will receive free the remaining numbers for 1906.

THE LIVING AGE CO.

6 BEACON STREET, BOSTON

Please mention THE AMERICAN NATURALIST

VOL. XLI, NO. 483 MARCH, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	Studies on the Ophioglossaceæ	PROF. D. H. CAMPBELL	139
II.	Polygamy and other Modes of Mating among Birds	DR. R. W. SHUFELDT	161
III.	On the Wood Rails, genus Aramides, occurring north of Panama	OUTRAM BANGS	177
IV.	Notes and Literature: *Biology*, The Reception of the Mutation Theory, Monument to Theodor Schwann, Fitch's Basis of Mind and Morals; *Geology*, The Reconstruction of the Continents of Tertiary Times, The Mountains of Cape Colony, Natural Mounds, Ancient Glacial Periods; *Physiology*, Hough and Sedgwick's Physiology; *Zoölogy*, Guyer's Animal Micrology, Mollusca of Illinois and Michigan, A Monograph on Anurida; *Botany*, A popular book on Canadian Wild Flowers, Notes, The Journals		189

BOSTON, U. S. A.

GINN & COMPANY, PUBLISHERS

29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca.*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Cornell University*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in Anthropology, General Biology, Zoology, Botany, Paleontology, Geology and Physical Geography, and Mineralogy and Petrography. The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; and in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, critical reviews of recent literature, and a quarterly record of gifts, appointments, retirements, and deaths.

All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to THE AMERICAN NATURALIST, Cambridge, Mass.

All business communications should be sent direct to the publishers.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *March, 1907* No. 483

STUDIES ON THE OPHIOGLOSSACEÆ

DOUGLAS HOUGHTON CAMPBELL

THE family of the Ophioglossaceæ comprises the three genera—Ophioglossum, Botrychium and Helminthostachys, which are all evidently related, but whose affinities with the other Pteridophytes are not so clear, and there is a good deal of difference of opinion as to where they should be placed. Most botanists agree that the Ophioglossaceæ are related to the true ferns, but this view is not universally accepted, although the results of the more recent investigations tend to strengthen this conclusion.

The most marked feature of the family is the peculiar fertile leaf segment or spike; and the present paper is mainly concerned with the question of the morphologic nature of this sporophyll.

During the past year the writer had an opportunity of collecting a large amount of material of the Ophioglossaceæ in Ceylon, Singapore and Java. This included several species of Ophioglossum, one of Botrychium, and the monotypic Helminthostachys,— so that it has been possible to make a first-hand study of all the genera belonging to the family. The following account of the morphology of the leaf is based mainly upon a study of this material.

THE MORPHOLOGY OF THE SPOROPHYLL.

In all of the Ophioglossaceæ the sporophyll consists of a fertile and a sterile segment. The former (Figs. 1, 3, 4, 6, 7) is a stalked structure, the peduncle being often very long. The sporangia are in two rows in Ophioglossum, but in the other genera the fertile portion of the spike is more or less extensively branched,

this being very marked in the larger species of Botrychium. The two segments of the sporophyll may be almost entirely separate, *e. g.*, *Ophioglossum bergianum*, *Botrychium ternatum*, or the fertile segment may be apparently an outgrowth of the base of the sterile segment or from above its base.

The earlier views of the morphologic value of the fertile leaf segment were strongly influenced by the prevailing theory that the fertile portion was a secondary development of originally sterile leaf tissue, and therefore must be homologized with some portion of the sterile leaf. The belief more generally current at present that the fertile structures of the sporophyll are older than the sterile ones, inclines toward a different interpretation of the real nature of the fertile segment.

Bower (Studies in the Morphology of Spore-producing Members, II, Ophioglossaceæ. London, 1896) has given a very complete account of the different theories that have been advanced to explain the morphology of the fertile spike in the Ophioglossaceæ, and we shall merely give here a brief summary of the more important of these. Mettenius (Farne des Bot. Garten zu Leipzig. 1856, p. 119) regarded the two parts of the leaf as of equal importance, but gives no data as to their method of origin,—whether by the equal branching of a common primordium or otherwise. Later writers, *e. g.*, Holle (Bot. Zeit. 1875, p. 271) and Goebel (Schenk's Handbuch, vol. 3, p. 111) consider the fertile spike as the equivalent of the fertile pinnæ of such a fern as Aneimia. The former considers the single median spike to be the result of the coalescence of two lateral pinnæ; the latter as a single pinna which arises in a median position.

Bower himself has made the most complete study of the development of the spore-bearing parts of the Ophioglossaceæ that has ever been made. He concludes that the spike of Ophioglossum is morphologically equivalent to the single sporangium of Lycopodium. In this view he has the support of Strasburger (Bot. Zeit., 1873) and Celakovsky (Pringsheim's Jahrb., 1884, vol. **14**). Bower has, however, more recently described a most remarkable species of Ophioglossum (Ann. of Bot. **18**, p. 205, 1904) *O. simplex* Ridley, which makes possible another interpretation of the nature of the spike, *i. e.*, that it is a terminal and not a lateral organ. The writer (Mosses & Ferns, 2d edit., p. 600) in view of the dis-

covery of this remarkable form, has ventured the hypothesis that in *O. pendulum* the sporangiophore may also be terminal. In order to make a thorough investigation of the question, the collections of material already referred to were made and the results of this study and the conclusions to be drawn from it are given in the present paper.

THE GENERAL MORPHOLOGY OF THE SPOROPHYLL.

Ophioglossum.

The genus Ophioglossum comprises, according to Bitter (Engle- & Prantl, Die Naturlichen Pflanzenfamilien, 1 Theil. Abt. 4, p. 466) about thirty species, but it is probable that the number is much greater, as the species have not been critically studied in some regions where the genus is well represented. Bitter recognizes three sections of the genus, Euophioglossum Prantl, including most of the terrestrial species; Ophioderma Presl, with *O. pendulum* L. and *O. intermedium* Hooker; and Cheiroglossa Presl. with the single species, *O. palmatum*. The subgenus, Rhizoglossum Presl, is also sometimes recognized to include the single species *O. bergianum*.

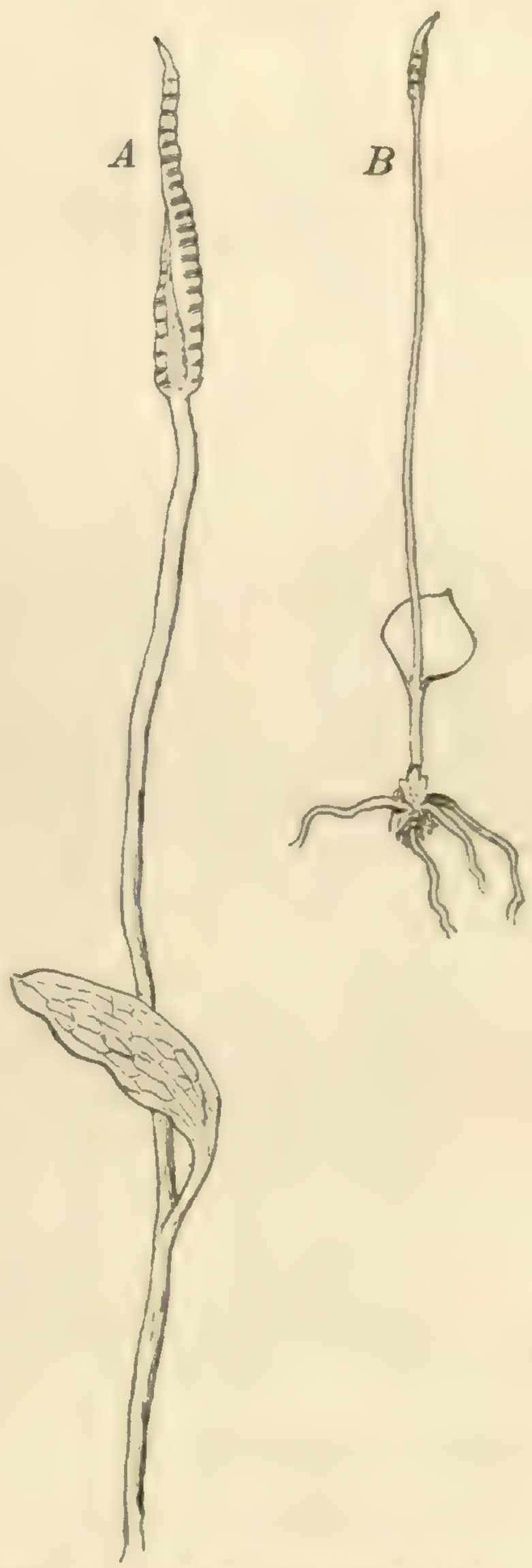


FIG. 1.— *A*, Sporophyll of *Ophioglossum moluccanum* Schlecht. natural size; *B*, Small form of *O. moluccanum* (?) natural size.

The great majority of the species belong to the first section, Euophioglossum. The writer collected a number of species in Ceylon and Java, but it was found very difficult to identify them, as in neither the collections at Peradeniya nor Buitenzorg was the genus well represented, and there is evidently very much confusion as to the species.

Raciborski, who has published a list of Javanese Pteridophytes (Die Pteridophyten der Flora von Buitenzorg, Leiden, 1898) gives only one terrestrial species, *O. moluccanum* Schlecht.; but it is evident from the writer's collections that there are at least four species belonging to Euophioglossum in western Java and possibly more.

What seems to be the typical *O. moluccanum* (fig. 1, A) is a species of moderate size. The specimen shown has a sterile leaf somewhat smaller than usual, but otherwise is typical. One of the smaller forms of the same (?) species is shown in fig. 1, B. In both of these the sterile lamina is small, while the peduncle of the spike is very long and not very much inferior in thickness to petiole below the junction of the spike and the sterile lamina. Most of the other species of the section, *e. g.*, *O. vulgatum* L., *O. californicum* Prantl, *O. reticulatum* L., etc., agree in the main with *O. moluccanum*, and in none of these is there anything in the external morphology of the adult sporophyll to forbid the assumption that the sterile lamina is a lateral appendage of the spike.

The second section of the genus, Ophioderma, comprises *O. pendulum* L., *O. intermedium* Hook. and probably also *O. simplex* Ridley. In the latter species (fig. 2), which was discovered by Ridley in Sumatra, the fertile leaf consists of a narrow basal part without any lamina, terminated by a spike similar to that in *O. pendulum*, and it was assumed to be the nearest relative of this species. There is, however, no peduncle developed as is the case in *O. pendulum* and *O. intermedium*. It is well known that in *O. pendulum* (see Fig. 3) the short peduncle of the spike which apparently arises from the lamina itself, is continued into a sort of thickened mid-rib which is not developed above the insertion of the peduncle

FIG. 2. — Plant of *Ophioglossum simplex* Ridley × ⅔ (after Bower).

of the spike, and the latter may very well be interpreted as the apex of the leaf, the lamina being lateral and closely coherent with its basal portion.

In all the species of Ophioglossum the growth of the basal part of the young sporophyll is very much more active than that of the lamina which remains relatively small, although the young spike is conspicuous in the early stages. This is especially marked in *O.*

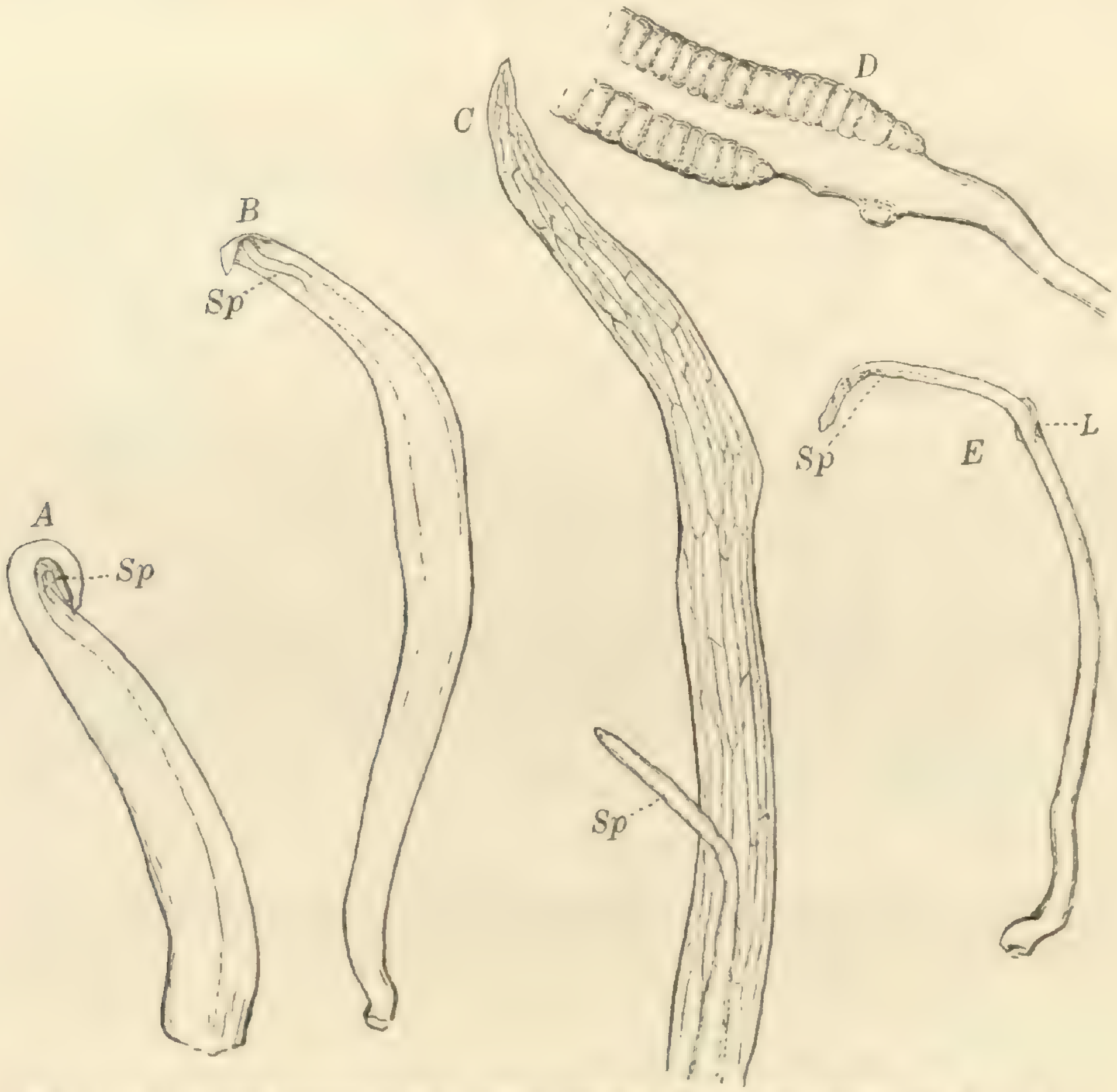


FIG. 3.— *A*, Young sporophyll of *Ophioglossum* (*Ophioderma*) *pendulum* L.. × 2; *B*, an older stage, natural size; *C*, a still older stage; *D*, base of a large spike, natural size; *E*, a small sporophyll in which the sterile lamina, *L*, is very greatly reduced, natural size.

pendulum (Fig. 3). This is the largest of the genus, and is a striking epiphyte of the moist tropics of the old world, extending, however, to the Hawaiian Islands. The specimens figured were collected in the botanical garden at Singapore.

In the youngest specimen shown (Fig. 3, A), the thick fleshy

leaf base terminates in a very small pointed lamina that is usually bent over, suggesting the circinate vernation of the true ferns. In most of the terrestrial species of Ophioglossum the young leaf is folded straight in the bud. Under the arched hood formed by the lamina is the young spike (*Sp.*) which almost equals the lamina in length.

Fig. 3, B, shows a somewhat older stage. The leaf has now become somewhat flattened, but there is no clear demarkation between the petiole and the small lamina. The fertile segment, which shows as yet no differentiation of the peduncle and spike, is conspicuous, and merges gradually into the thick petiole of the leaf whose margins are more or less distinctly winged and pass imperceptibly into the lamina above the insertion of the fertile segment. The interpretation of the latter as terminal and the sterile portion as a lateral appendage coherent with it would seem entirely plausible. An interesting case is shown in Fig. 3, E, where the lamina is almost entirely suppressed, and the terminal character of the spike is very evident.

As the leaf develops there is a very great increase in size of the lamina, which, in some of the largest individuals collected in Ceylon and Java, reached a length of one and one-half metres, or even more. These large leaves usually have the lamina dichotomously divided, and strikingly resemble the long drooping leaves of some species of Platycerium. Nevertheless even in these larger leaves the segments are quite destitute of a mid-rib. This stops at the base of the peduncle of the spike into which it is continued. The spike in these large specimens is correspondingly large, and sometimes attains a length of 25 to 30 centimetres, with a breadth of more than a centimeter (Fig. 3, D).

Undoubtedly allied to *O. pendulum* is the rare *O. intermedium* Hook. (Fig. 4). This is also perhaps the nearest ally of *O. simplex*. In the ordinary form (Fig. 4, A, B) this is not unlike a small specimen of *O. pendulum*, but it is rigidly upright instead of lax and drooping, the peduncle is longer and the lamina of the leaf much smaller and more sharply separated from the petiole. As in *O. pendulum*, however, the petiole is prolonged into the peduncle of the spike with the same mid-rib like thickening, caused by the coherence of the basal part of the peduncle with the lamina.

Even in the small number of specimens collected (the plant is an extremely rare one) a number of very interesting variations were found, some of which approximated quite closely the condition found in *O. simplex*. In these the lamina was greatly reduced, and in one case (Fig. 4, E) formed merely the narrow wing along the margin of the petiole and peduncle of the spike. In the other

FIG. 4.— *Ophioglossum* (*Ophioderma*) *intermedium* Hook. several plants reduced about ½, showing variation in form; *K*, root-bud.

cases the lamina was wider and its apex free, but even in these the lamina was very small, and the terminal position of the spike extremely evident (C, D).

In both *O. pendulum* and *O. intermedium* the spike is more flattened than in the section Euophioglossum, and the central sterile portion wider in proportion. Stomata are almost entirely absent from the spike of *O. pendulum*, and the few that are occasionally found are confined to the central part. In *O. intermedium* the stomata are more numerous than in *O. pendulum*, but much less numerous than in *O. moluccanum*, for example, where they also occur upon the epidermis of the wall of the sporangium.

The third section, Cheiroglossa, represented by the monotypic *O. palmatum* L. of the American tropics differs from the others of the genus in having, usually, several spikes which are not generally borne in the median plane of the leaf, but are inserted near the margin. Bower (loc. cit., figs. 116–117) has shown that there may occasionally be a single spike which is then borne in the same position as in *O. pendulum*. He supposes that *O. palmatum* has been derived from the form with a single median spike like that of *O. pendulum* by branching of the spike, which not infrequently occurs in the latter species as well as in some others. The separation of the originally connected spikes he assumes has been the result of the great expansion of the lamina, which is much broader in *O. palmatum* than in any other species. Unfortunately the developmental history of the sporophyll in *O. palmatum* is quite unknown.

THE YOUNG SPOROPHYLL.

The differentiation of the two parts of the sporophyll takes

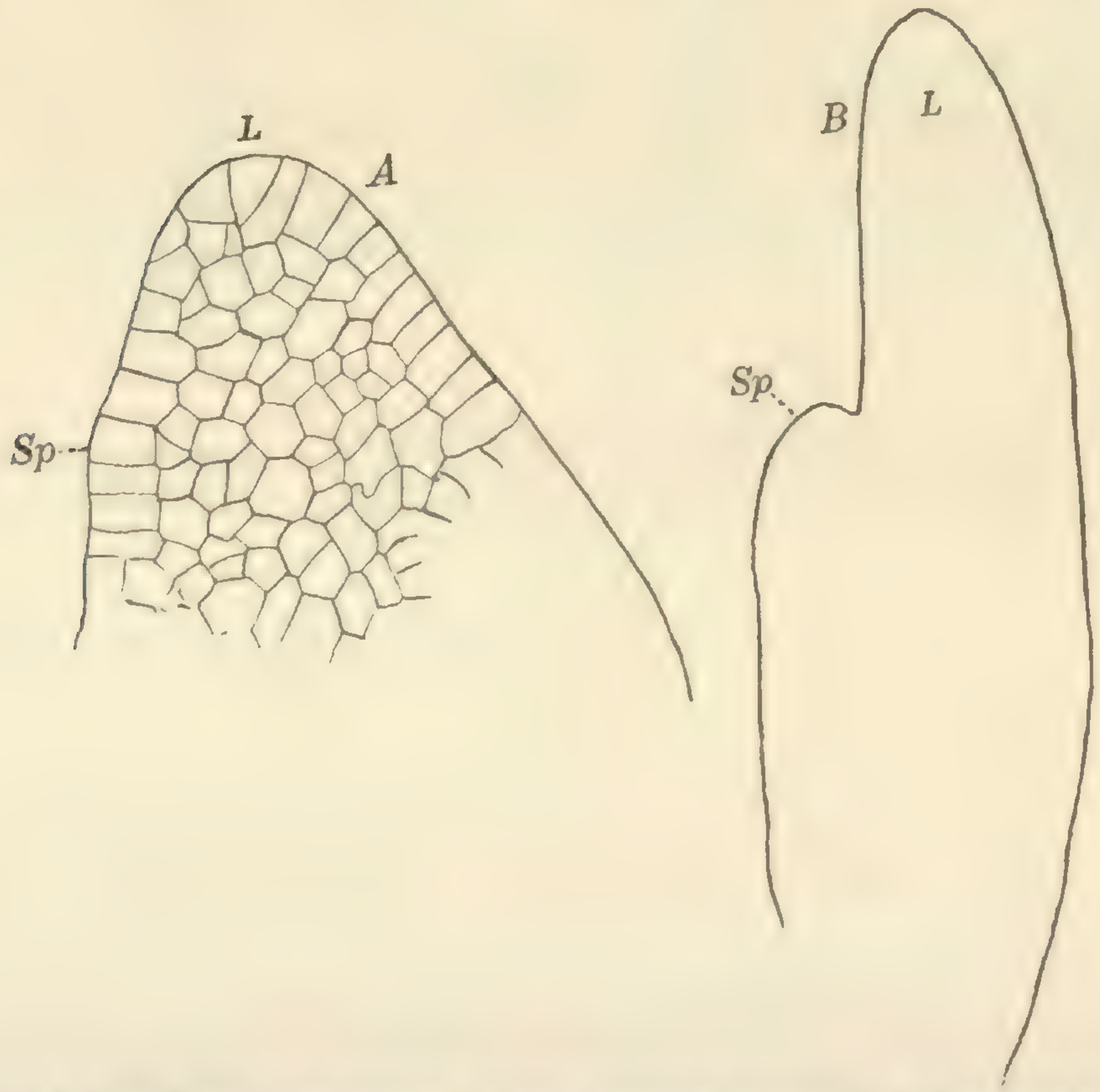


FIG. 5.— *A*, Nearly median section of a very young sporophyll of *O. pendulum*, × about 90; *B*, section of an older sporophyll, × 50; *Sp*. the apex of the spike; *L*, the sterile leaf-segment.

place at a very early period, and at this time the fertile spike is already evident as a conspicuous protuberance on the adaxial side of the leaf rudiment not far from its apex. Both divisions of the young sporophyll terminate in an apical cell, and both apparently grow in the same way.

Fig. 5, A, shows a nearly median section of a very young sporophyll of *O. pendulum*. This is a broadly conical body upon whose inner (adaxial) face there is a slight prominence (*Sp.*) the apex of the young spike. Fig. 5, B, shows an older, but still very early stage, in which it is evident that the spike rudiment extends completely to the base of the young leaf, with which it is adherent except at the extreme tip. The apex of the young spike is directed upward and its axis is almost parallel with that of the sterile leaf segment. From Bower's figures of corresponding stages in *O. vulgatum* it is clear that a very similar condition of things prevails in that species. In such a stage as that shown in Fig 5, B, the relation of the fertile and sterile segments is not unlike that of a stem apex and leaf, and the condition of things here present would very well lend itself to the interpretation of a terminal spike with a subtending sterile lamina. At this stage the vascular bundles are not yet differentiated, and the arrangement of these in the young leaf still remains to be made out.

Fig. 6.—A, Plant of *Botrychium ternatum* Sw., × ½; (after Luerssen); *B*, base of the spike in *B. lanuginosum* Wall., slightly enlarged.

Botrychium.

In the second genus, Botrychium, most of whose species are plants of the temperate zones, both the fertile and sterile segments of the leaf as is well known, except in some

simple forms of *B. simplex*, are more or less extensively branched. This is especially marked in such large species as *B. virginianum* and *B. lanuginosum*.

The relation of the fertile and sterile periods is essentially the same as in Ophioglossum, and there is the same variation in the point of divergence of the two leaf segments. Thus in *O. obliquum* Muhl. the two are separated almost to the base. In *O. virginianum* and *O. lanuginosum* (Fig. 6, B) the spike appears to arise close to the lamina of the leaf or even above its base. No material was available for a critical study of this point in *B. virginianum*, but in *O. lanuginosum* Wall. where (see Engler & Prantl, loc. cit., p. 471) it is stated that the spike arises from the base of the sterile segment; even a casual examination will show that this is more apparent than real (see Fig. 6, B). If the leaf be looked at from in front it is very evident that the peduncle can be traced for a long distance below the bases of the sterile leaf segments, although only the anterior face is free, the inner face and sides being completely adherent to the base of the sterile segments.

HELMINTHOSTACHYS.

A similar condition to that found in *Botrychium lanuginosum* prevails in the third genus, Helminthostachys (Fig. 7), a monotypic genus of the Indo-Malayan region. This is much nearer to Botrychium, in its general morphology, than it is to Ophioglossum, although, in the character of both the prothallium and fertile spike, it is to some extent intermediate in character between the two genera.

In Helminthostachys the sterile segment, as in most species of Botrychium, is ternately divided, and the anterior margins of the stalks of the two lateral leaf segments are continued as more or less conspicuous wings enclosing the adherent base of the peduncle.

DISTRIBUTION OF THE VASCULAR BUNDLES.

A careful study of distribution of the vascular bundles of the leaf was made in most of the species that were available, to see

how far this harmonized with the theory of the terminal nature of the fertile spike. The arrangement of the bundles has already

FIG. 7.— *A*, Sporophyll of a small specimen of *Helminthostachys zeylanica* Hook., × ½; *B*, base of the spike, natural size.

been studied in the commoner European species, *O. vulgatum*, *O. lusitanicum* and *B. lunaria*. Bower has also investigated this in *O. bergianum*, and more recently in *O. simplex*, *O. pendulum* and *O. palmatum* (loc. cit. 1904). Of these forms the writer has examined *O. pendulum*, and in addition to this a number of other species which have not been hitherto studied.

In all of the species belonging to the section Euophioglossum that have been examined, there is given off from the vascular system of the rhizome a single leaf trace which divides at the base of the leaf into two strands. This is probably the case also in all the forms associated with *O. moluccanum* (see Fig. 8). According to Prantl, in *O. lusitanicum* each of these two bundles gives off a branch toward the adaxial side of the petiole which unite and

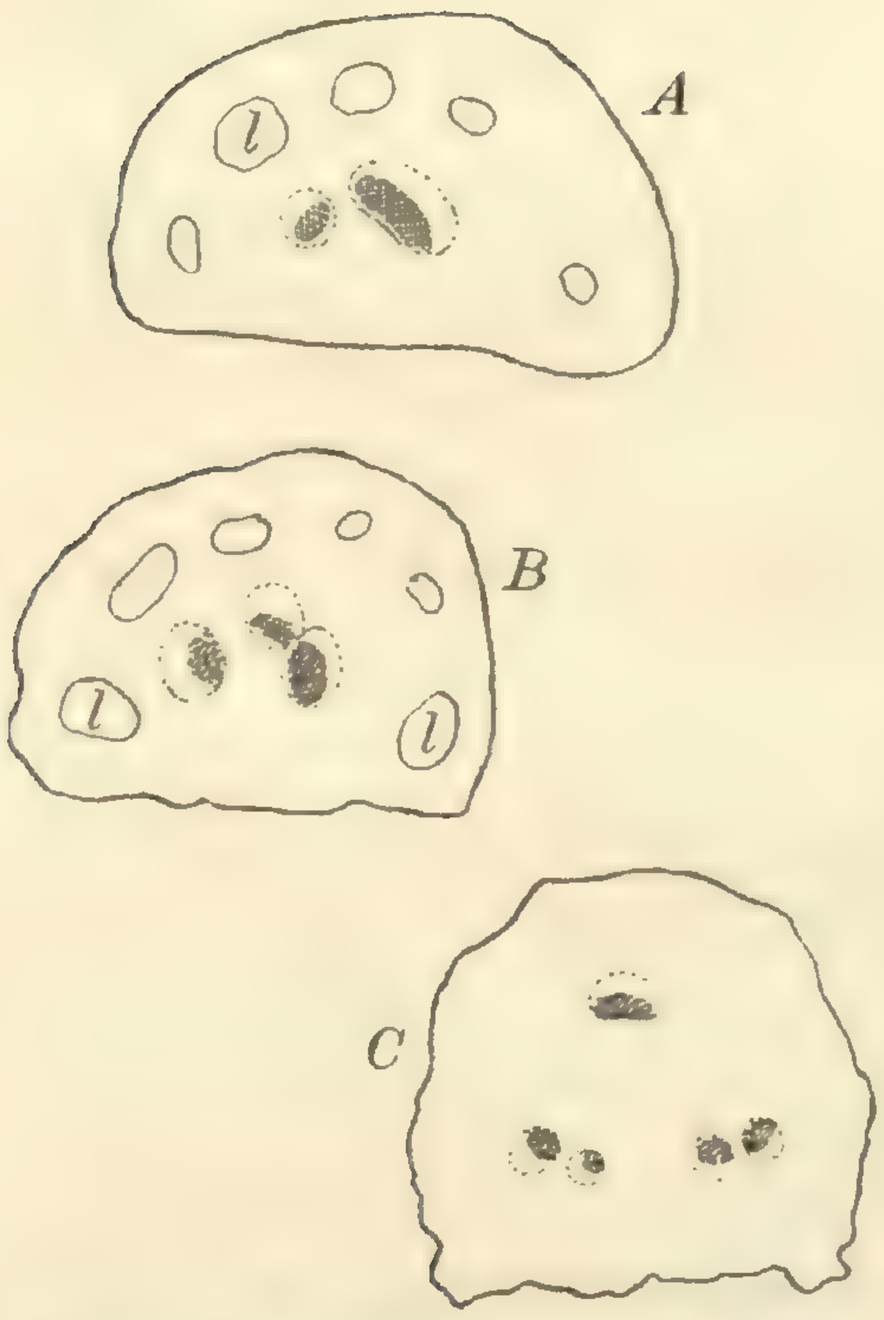


Fig. 8.—Three cross-sections of the lower part of the petiole of *Ophioglossum sp.*, × 25; *A*, *B*, at the base; *C*, higher up.

pass into the spike, the main trunks passing upward into the lamina. In the specimen shown in Fig. 8, which probably was not the typical *O. moluccanum*, while the leaf trace divides into two branches, as in *O. lusitanicum*, only one of these divided at the base of the leaf, so that at a point some distance above the base there are only three bundles, two of which are destined for the spike. The single bundle which is to supply the lamina is the result of the division of one of the two primary strands, the other half of which forms one of the adaxial bundles belonging to the spike.

O. MOLUCCANUM SCHLECHT.

A transverse section of the petiole in the typical *O. moluccanum*, made some distance below the point of separation of the two parts of the sporophyll (Fig. 9, A), shows four nearly equal vascular bundles, of which one is on the outer (abaxial) side, the other three on the adaxial side. As in all other species of Euophioglossum, these bundles are markedly collateral in structure. It is probable that the central adaxial bundle is due to the branching of one of the two adaxial bundles found near the base of the petiole.

If a section be made just below the point where the two parts of the leaf separate (Fig. 9, B), the three adaxial bundles are still recognizable, but the abaxial one has divided into several, which are evidently destined to supply the sterile leaf segment. A section taken a little higher up (C) shows plainly the bases of the two parts of the leaf. In the adaxial part, the peduncle of the spike, the original three adaxial bundles, are clearly evident, while in the lamina may be seen an increased number of bundles due to

the further ramifications of the abaxial bundles to form the reticulum of veins in the leaf segment. It is clear that in this species three of the four bundles of the petiole are continued unbroken into the spike, while only one of these contributes to the sterile leaf segment. This would certainly tend to confirm the view that the spike is the principal part of the leaf, and the lamina is secondary.

The base of the spike (Fig. 9, C, D) shows the three bundles, but above the base (E) these bundles may branch, so that a section higher up shows five bundles. The ramifications of the veins of the fertile part of the spike were not studied in detail.

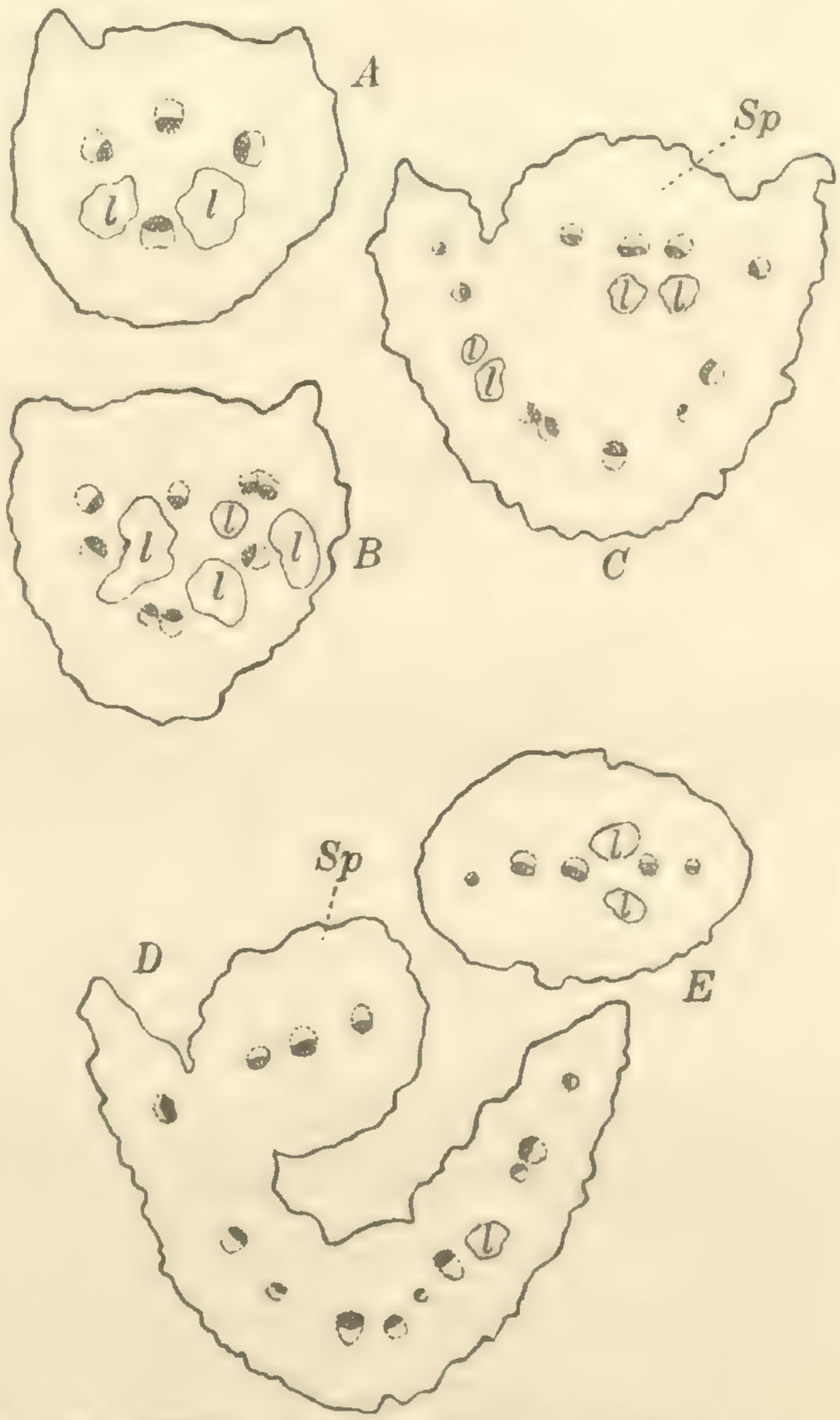


FIG. 9.— Five sections of the sporophyll of *O. moluccanum*; *A*, the petiole; *B*, *C*, intermediate; *E*, the peduncle of the spike; *l*, lacunæ; × 20.

OPHIOGLOSSUM SP.

Fig. 10 shows sections of a second form of Ophioglossum, collected at Buitenzorg, evidently specifically distinct from *O. moluccanum*. It was a plant of about the same size, but it differed both in the cordate sterile leaf and in the size and other characters of the spores. It is probable that Fig. 8, which shows the extreme lower part of the petiole, also belongs to this species. The lower part of the petiole in cross section shows but three bundles instead of four, the middle adaxial bundle being absent. In a section taken near the junction of the spike and lamina there were four abaxial bundles and five adaxial ones. It is not exactly clear as to the relation of the latter to the ramification of the two pri-

mary adaxial bundles, whose identity is not so clearly maintained as in *O. moluccanum*. In a section at the base of the lamina the

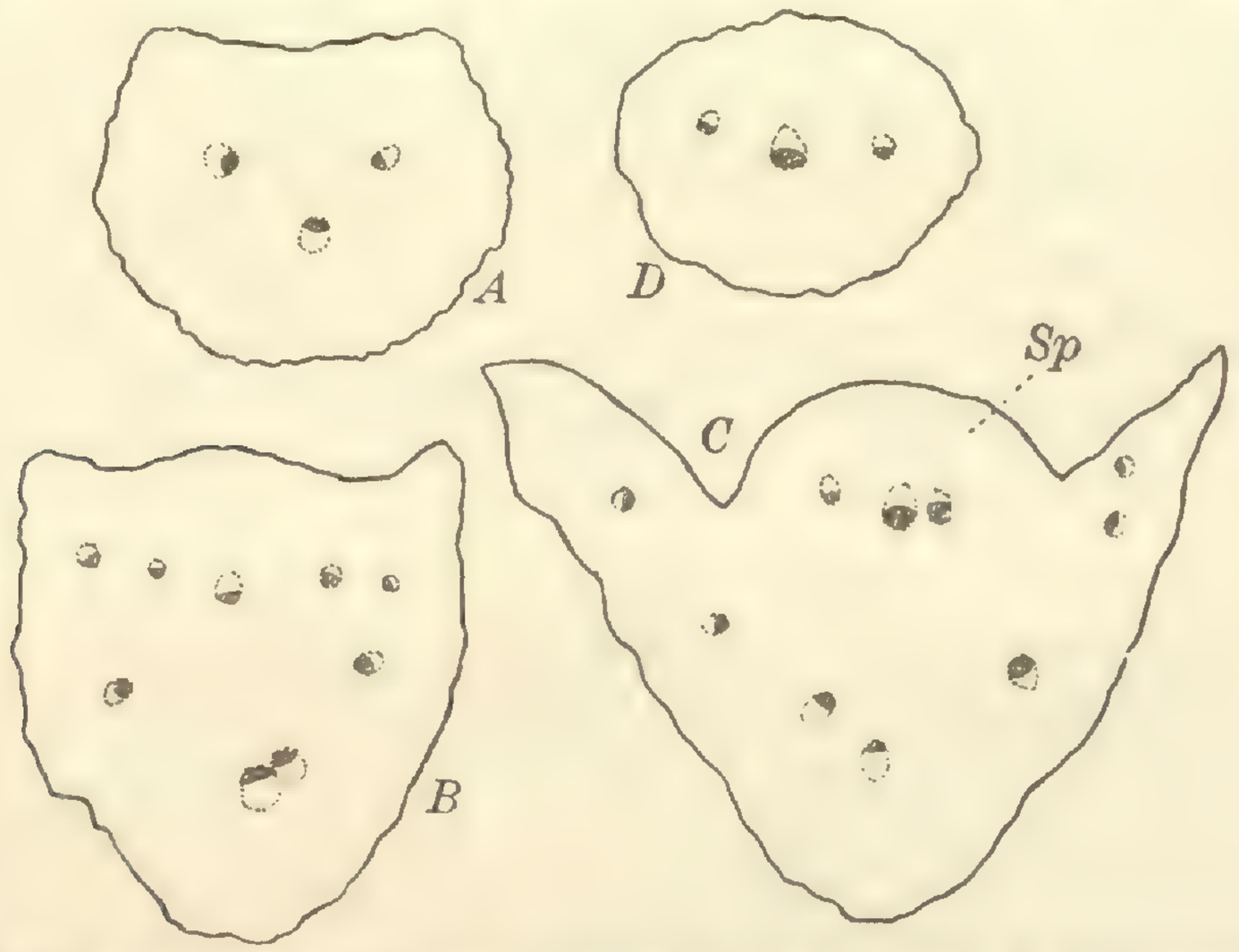


FIG. 10.— Four sections at different heights of the sphorophyll of *Ophioglossum sp.*; *A*, petiole; *B*, *C*, intermediate; *D*, peduncle; × 20.

arrangement of the bundles is very much the same as in *O. moluccanum*, and the three bundles of the spike are very similar. The triple arrangement continues into the spike, and a section made well above the base shows practically the same appearance.

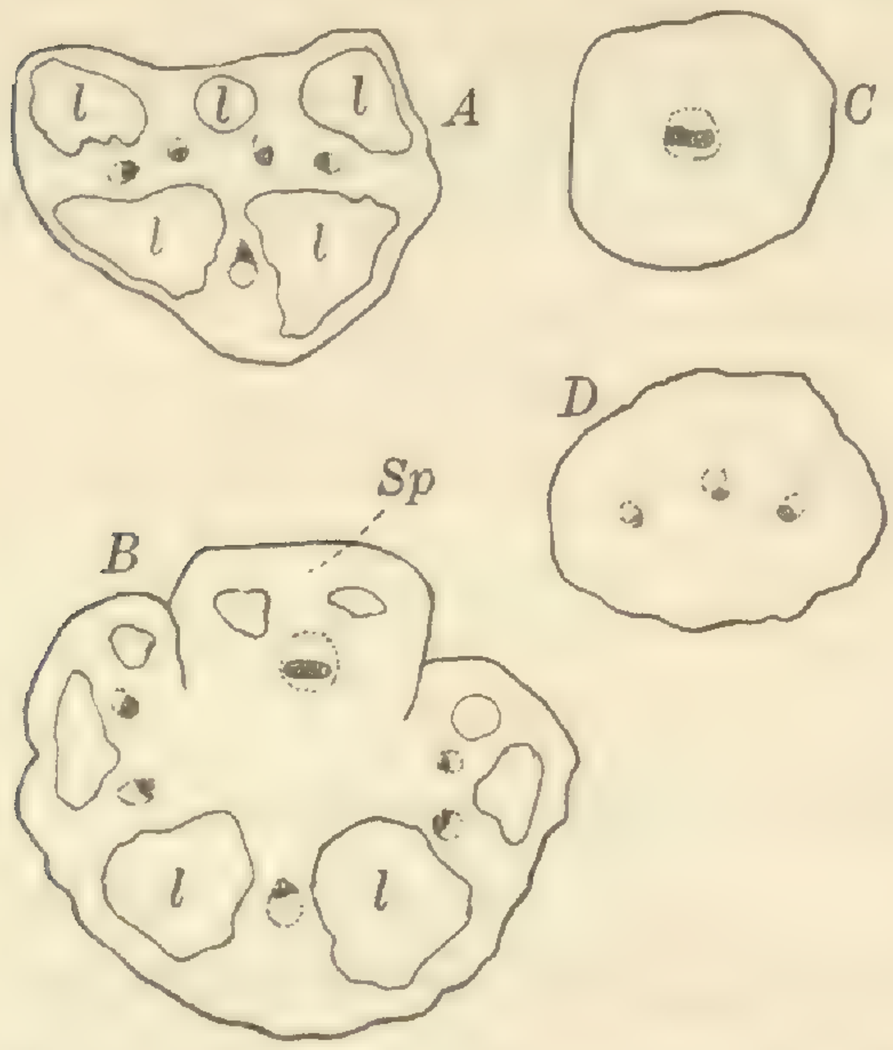


FIG. 11.—*Ophioglossum californicum* Prantl.; *A–C*, three sections of the sporophyll of a medium sized specimen; *D*, section of the peduncle from a larger specimen; × 20.

O. CALIFORNICUM PRANTL.

O. californicum is a small species from southern California. In the anatomy of the leaf it seems to follow pretty closely the description given by Prantl for *O. lusitanicum*. A section of the petiole (Fig. 11, A) shows four adaxial bundles, and a single abaxial one. If the section be made through the base of the peduncle and lamina (Fig. 11, B) the spike shows in some cases but a single large bundle, evidently formed by the coalescence of the adaxial bundles. There are five

bundles belonging to the lamina, of which the posterior one is apparently the original abaxial bundle, while the others are derived from the two outer of the four adaxial bundles. A large specimen which was examined showed three bundles in a transverse section of the peduncle (Fig. 11, D).

Ophioderma.

Bower has shown that in *O. pendulum*, *O. simplex* and *O. palmatum* there is not a single leaf trace, but the individual strands of the petiole join the vascular system of the rhizome directly. He also showed that the adaxial bundles which supply the spike in the fertile leaf of *O. pendulum* are quite absent from the petiole of the sterile leaf, which in section shows no bundles at all on the adaxial side. In the section Ophioderma the upper part only of the peduncle is free, the lower portion, as we have seen, being adherent to the lamina and merging insensibly into the common petiole of the sporophyll. Fig. 12 shows four sections at different heights from a leaf of *O. intermedium*. Near the base of the petiole there are five vascular bundles, of which the two on the adaxial side are noticeably larger than the three abaxial bundles. Somewhat higher up there are four adaxial bundles, evidently the result of a bifurcation of the two which are seen lower down. The three abaxial bundles remain unchanged except that they are somewhat further apart, corresponding to the broadening of the petiole at this point. Still higher up, where the base of the peduncle is coherent with the lamina, the former may be seen projecting somewhat from the leaf and containing three bundles, and the same number occurs in the free portion of the peduncle (Fig. 12, C & D).

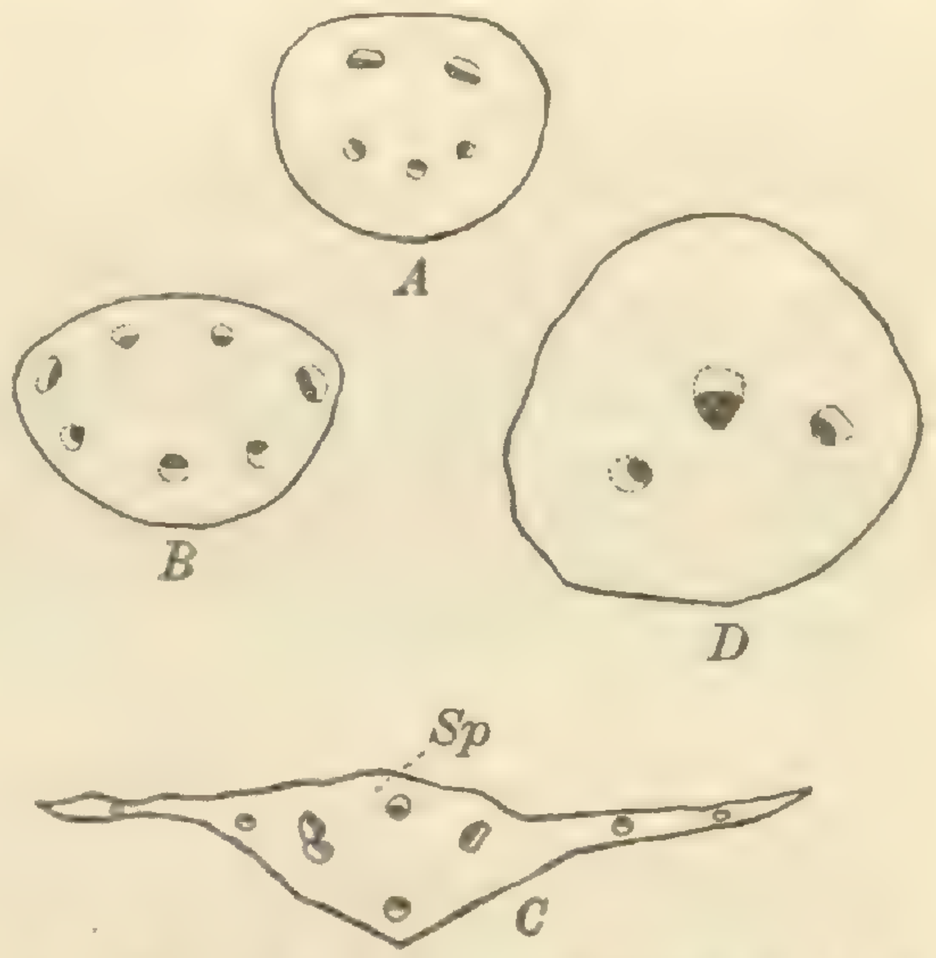


FIG. 12.— *Ophioglossum intermedium*; *A–C*, three sections of the petiole and lower part of lamina, × 6; *D*, section of free part of peduncle, × 20.

The very much larger leaves of *O. pendulum* show a correspondingly larger number of vascular strands. Fig. 13, A to D, shows sections through the petiole, base of lamina, and spike of a medium size specimen. In the former eighteen bundles could be seen, of which probably seven or eight are destined to supply the spike. In the basal part of the lamina six or seven adaxial bundles are plainly visible below the slightly projecting region which marks the coherent portion of the peduncle. In both this species and *O. intermedium* the free portion of the peduncle is comparatively slender, and the number of bundles less than in the broader basal part. In the specimen figured there were three bundles, of which the middle one was evidently doubled, and was clearly formed by the coalescence of some of the bundles before they left the adherent part of the peduncle. Higher up there were five bundles arranged in a semicircle. The same arrangement was found in the peduncle of a larger specimen (Fig. 13, E) taken from the spike which is shown in Fig. 3, D.

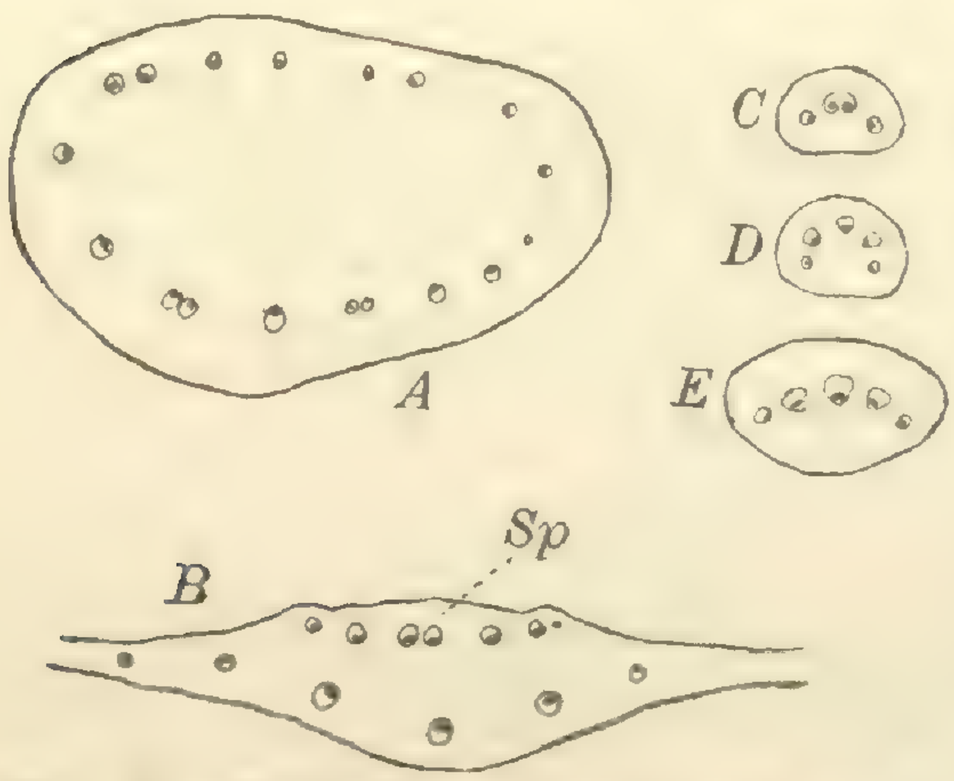


FIG. 13.— *Ophioglossum pendulum*; *A*, section of the petiole of the sporophyll; *B*, section of the base of the lamina and coherent peduncle, *Sp*; *C*, *D*, two sections of the free portion of the peduncle; *E*, section of the peduncle from a larger specimen; all figures × 4.

The complete absence of the adaxial strands in the petiole of the sterile leaf, even at its base, is a strong confirmation of the view suggested by both the older leaf and the younger stages that the peduncle really extends to the extreme base of the petiole and is joined directly to the rhizome.

BOTRYCHIUM.

The only species of Botrychium available for study was *O. lanuginosum* Wall. collected at Horton Plains in the uplands of Ceylon. The arrangement of the bundles in the leaf of this species agrees in the main with that of the other species that have been studied (see Bitter, loc. cit., p. 458). The leaf trace divides into

two at the base of the petiole, and these branches divide again somewhat higher up (Figs. 14, A to C). Of the four bundles thus formed, the two larger adaxial ones are those which supply the spike, the smaller abaxial ones supplying the lamina. In larger

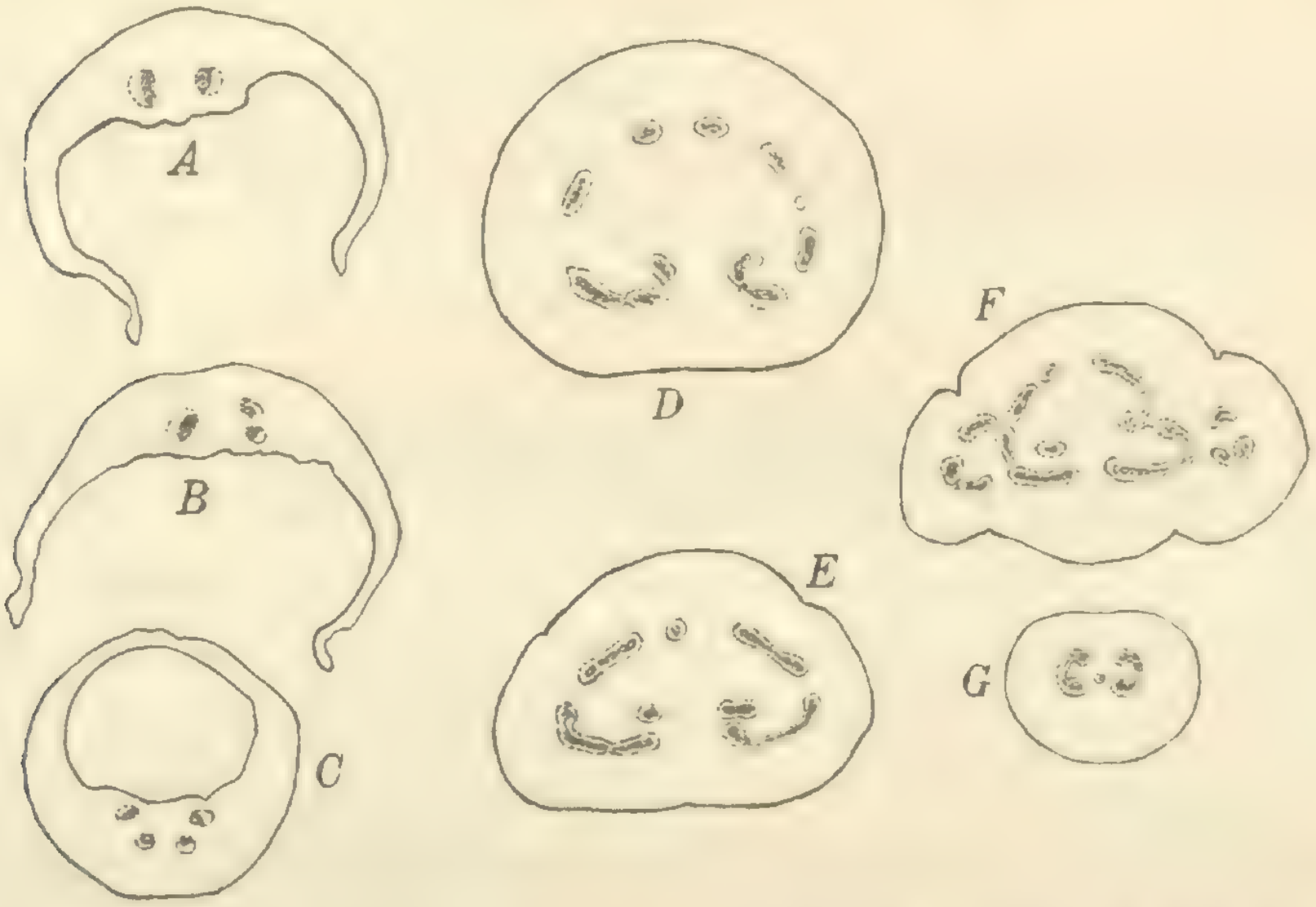


FIG. 14.— *Botrychium lanuginosum*; *A*, *B*, *C*, Sections through the base of the petiole; in *C*, the position is reversed from that of the others; *D–G*, sections of the petiole and upper part of the sporophyll of another specimen; × 4.

specimens of this species (Fig. 14, D), and the same is true in *B. virginianum*, there may be a subsequent branching of some of the bundles, so that a cross section of a stout petiole shows a larger number of bundles, sometimes as many as ten.

Sections made at the junction of the spike and lamina (Fig. 14, E) show anastomoses of some of the bundles which appear elongated in section, but there seems to be no regular rule governing the fusion of these. It is not quite clear whether any branches are given off from the spike bundles into the lamina, but this is probably the case in regard to the two lateral segments of the lamina. Within the peduncle of the spike in the larger specimens (Fig. 11, G) the two original bundles are again clearly defined, but in some of the smaller specimens these may be completely united into a single central bundle.

Helminthostachys.

Farmer & Freeman (On the Structure and Affinities of Helminthostachys zeylanica, Ann. of Bot. **17**, p. 421, 1899) state that in Helminthostachys there is, as in Euophioglossum and Botrychium, a single leaf trace which afterwards divides into several, usually seven or eight, within the petiole. As we have already seen, although the spike in Helminthostachys arises apparently from the base of the lamina, in reality its origin is lower down, and it may be traced for a long distance below the insertion of the sterile segments.

In a section made near the base of the petiole, it appears almost circular in outline with a ring of separate bundles. On the adaxial side, however, there are two other bundles within the outer circle. The number of bundles in the larger specimens collected by the writer was decidedly greater than that given by Farmer & Freeman (see Fig. 15, A). Higher up the section is no longer round, but slightly lobed, indicating the bases of the three branches of the ternately divided lamina, and on the adaxial side can be plainly seen a fourth lobe, which marks the position of the spike. This is bounded by two more or less conspicuous bodies, the sections of the wings that extend down the petiole from the lateral leaf lobes (Fig. 15, B & C). In this region the separate bundles of the basal part of the petiole are more or less coalescent, but the two adaxial bundles remain separate and are those which later extend into the spike. Still higher up the spike becomes more evident, and the two bundles belonging to it still more clearly separated. In the free portion of the peduncle the two crescent shaped bundle

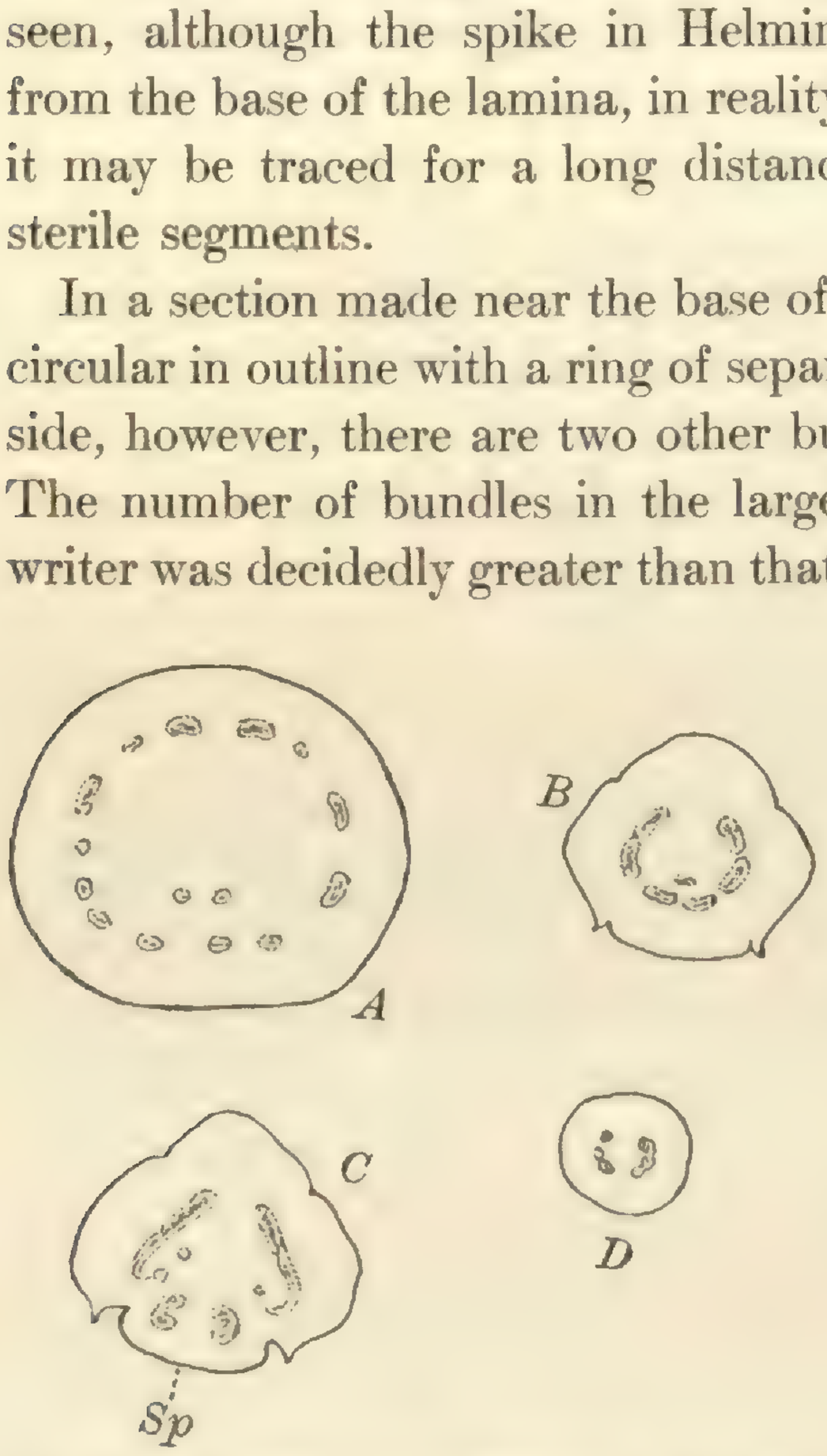


Fig. 15.— *Helminthostachys zeylanica*; *A*, section of the petiole of a large specimen, near the base; *B*, *C*, sections higher up, of the petiole of a smaller specimen; *D*, section of the peduncle; × 15.

sections are seen (Fig. 15, D), but it is evident that they are really composed of several coalescent bundles. A slight indication of this can be seen also in the adherent basal portion of the peduncle.

CONCLUSIONS.

From a study of the distribution of the bundles in the leaf it is evident that the bundles which supply the spike are not secondarily given off from the main bundles of the petiole, but are themselves the adaxial bundles which can be traced from the base of the petiole into the spike. This would indicate that the spike is not a secondary development upon the leaf, but is a primary portion of it. From a study of the earlier stages of the young sporophyll as well as from the conditions shown in *O. simplex* and certain forms of *O. pendulum* and *O. intermedium*, there seems to be little question that the spike is really a terminal structure, and the writer is inclined to believe that in all cases the spike may be regarded as the apex of the leaf structure and the lamina as lateral with regard to it. If this view be not accepted, it would seem necessary to return to the old view of Mettenius, that the leaf is divided into two equal branches.

FIG. 16.— Section of the prothallium, *Pr*, and young sporophyte of *Ophioglossum moluccanum*: the latter consists simply of the terminal leaf, *L*, and the primary root, *R*; × 15.

In connection with the question of the terminal position of the sporophyll, the position of the leaf in the embryo may be cited. In *O. moluccanum* — and the same is true in *O. pedunculosum* described fifty years ago by Mettenius,— the young sporophyte (Fig. 16) develops at first only a leaf and root, the definitive sporophyte arising later as an endogenous bud from the primary root. The first leaf must be considered a strictly terminal organ. This embryo corresponds exactly to what might be expected if the hypothesis advanced by the writer — that Ophioglossum probably arose from some form resembling Antho-

ceros — be true. This hypothesis assumes that, by the development of a root from the lower part of the sporophyte and a complete septation of the sporogenous tissue of the sporogonium so that something resembling the spike of an Ophioglossum resulted, there would be formed a plant not very unlike *O. simplex*. We actually have in the embryo sporophyte of *O. moluccanum* a plant which consists simply of leaf and root. Of course the leaf is not sporogenous, but the ancestral form must have developed a sporogenous structure comparable to the spike before the foliage leaf arose. The latter presumably was formed as a lateral outgrowth of the sporogenous portion, as there seems to be some evidence is the case in the young sporophyll of the living species.

THE AFFINITIES OF O. INTERMEDIUM HOOKER.

Ophioglossum (*Ophioderma*) *intermedium* Hook. is apparently a very rare plant. It was originally described by Hooker from

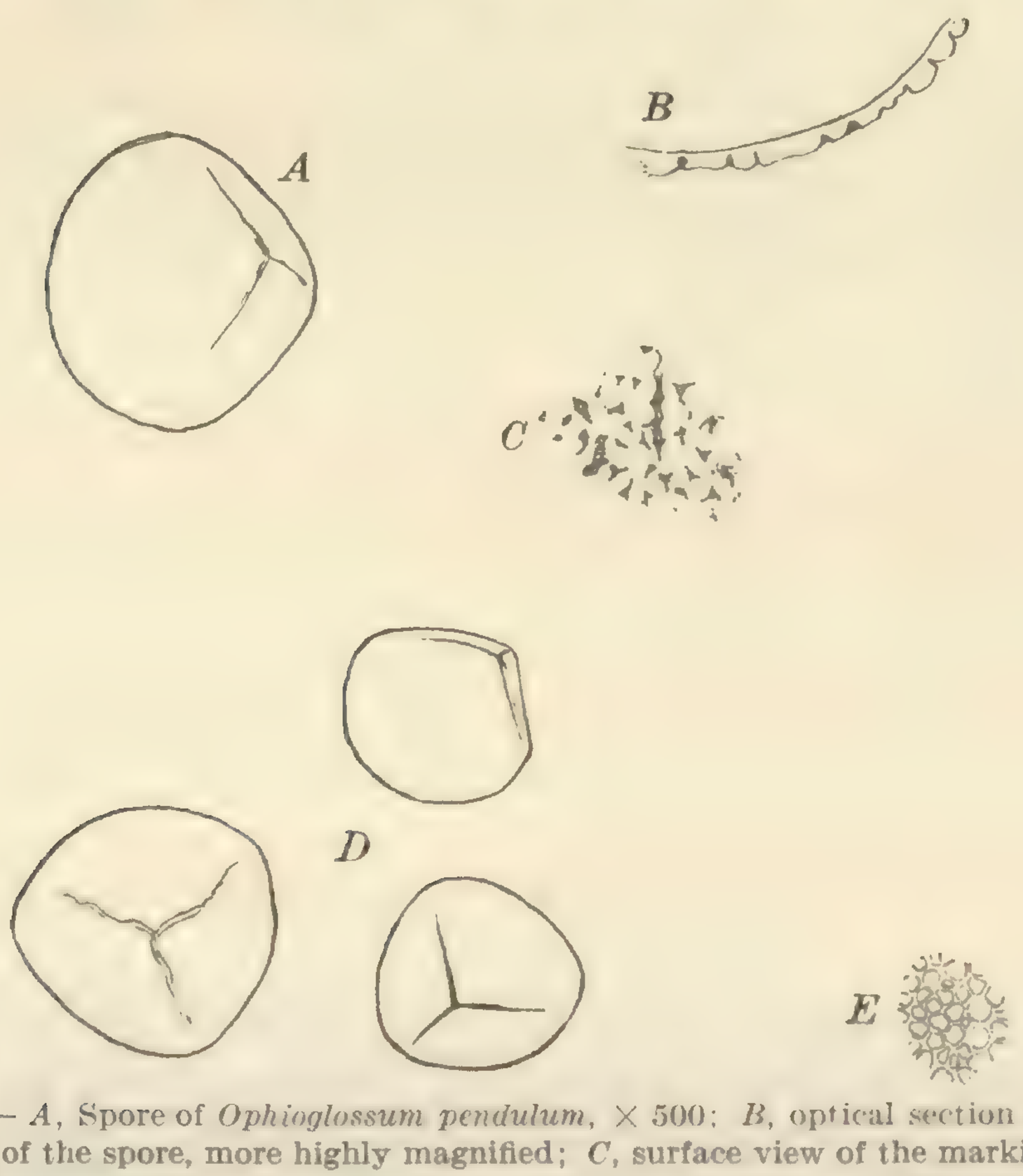


FIG. 17.— *A*, Spore of *Ophioglossum pendulum*, × 500; *B*, optical section of the wall of the spore, more highly magnified; *C*, surface view of the markings of the spore-membrane; *D*, three spores of *O. intermedium*, × 500; *E*, markings of the surface of the spore.

material collected in Sarawak in Borneo. When the writer was in Singapore inquiries were made at the botanical gardens as to the possibility of obtaining material of this species, but it was found that the original locality was lost, and the plant had not apparently been collected since it was first sent to Hooker.

The writer, however, found that this species had been collected near Buitenzorg by Mr. J. J. Smith, of the herbarium of the garden there. He was kind enough to accompany the writer to the place where it had been collected, and it was thus possible to obtain a fair amount of material which was enough to show that the plant is certainly quite distinct from *O. pendulum*, of which it has been supposed (Bitter, loc. cit., p. 469) that it was a mere form, perhaps due to its terrestrial habit. In Buitenzorg it grew in a plantation of bamboo — usually in the accumulation of humus and earth about the roots of the clumps of bamboo. It is a small plant (see Fig. 4) and in its stiff upright habit and much longer peduncle presents a very different appearance from any form of *O. pendulum* — although it is evident that it belongs to the same section of the genus. The plants grew from a small tuberous body apparently developed as a root bud (Fig. 4, B, E) and in this respect as well as in the occurrence of such forms as that shown in Fig. 4, E, where the lamina is almost wanting, it approaches *O. simplex*, with which it may be pretty closely allied. It differs, however, in other respects than that of its habit, from *O. pendulum*. The spores (Fig. 17, D) are decidedly smaller than those of *O. pendulum*, and the delicate reticulate markings of the epispore (Fig. 17, E) are very different from the markings in the latter species.

STANFORD UNIVERSITY
Jan., 1907

POLYGAMY AND OTHER MODES OF MATING AMONG BIRDS

R. W. SHUFELDT

For several years I have devoted much time to a study of the phenomena of sex in vertebrates, comparing those of the lower forms with the features presented by man. Much of the matter thus obtained is now in the publisher's hands but some of it is presented here.

The nature of man, his customs, habits, and institutions, his mental and physical characteristics cannot be fully and intelligently understood unless all of our stock of accumulated facts are studied in the light of what we know to obtain along the corresponding lines among all animals below man. That is to say, it is simply impossible to comprehend the morphology of man, unless our studies of it are made comparative with our knowledge of the anatomy of all other animals. So too with all else manifested on the part of our species;— to get at the origin of all things in man and his customs, his crimes, and his passions, we are obliged to trace them down through the scale of living forms below him. It holds in our researches into the science of society, and it was Letourneau who said "When once it is established that man is a mammal like any other, and only distinguished from the animals of this class by a greater cerebral development, all study of human sociology must logically be preceded by a corresponding study of animal sociology. Moreover, as sociology finally depends on biology, it will be necessary to seek in physiological conditions themselves the origin of great sociological manifestations." [1]

It has been recently, with such thoughts as these in mind, that I have been making some comparisons of the various forms of marriage as we find it among different races of mankind; the question of divorce; and the part played in the marital relations by sexuality. Following the biological methods of comparison

[1] The Evolution of Marriage, p. 2, 1900.

and derivation, I attempted to bring together what I knew of the matter of mating among animals generally, carrying my investigations into the various groups of fishes, reptiles, birds and mammals. It is a very well known fact that with respect to our own species, we meet in one part of the world or another, people who practice every form of sexual relation, to say nothing of what is met with along the lines of pervertism in such matters. Even in the United States, we meet with any number of cases of marriage devoid of all ceremony (anarchists); of free love; of monogamy; of promiscuity; of polygamy and bigamy; of legalized concubinage (South Carolina); and of the divers unnatural relations of the sexual perverts and inverts. Polyandry, that rare and exceptional conjugal form, where the one wife has two or more husbands, has never been instanced among us, so far as I am aware. No such sexual association is met with among mammals below man, and never among birds.

It is in this latter class of vertebrates that we meet with some of the purest types of, as well as some of the most interesting examples of the conjugal relation, and it is to a comparative consideration of some of these that the present article will be devoted.

In reviewing the material for this purpose at hand, I have drawn largely upon my own ornithological observations and studies extending over a period of forty or more years. Then I have consulted such works upon ornithology as I find in my private library. With respect to the latter, I am obliged to confess my surprise at the inadequacy of the accounts, and the marked variance often exemplified in the statements of different authors of recognized standing and reputation on the subject. Very few books at my command pretend to make any comparisons between the mating habits of birds and the marriage customs of various peoples, but there are a few.

Beyond the matter of the different procedures of courtship in the case of birds, there are no further ceremonials with them as in the case of many, indeed, the majority of the races of mankind. So that, in the abstract, polygamy in birds means exactly the same thing as human polygamy, and so on for monogamy, promiscuity and other practices. Taken in the abstract, and barring opinions to the contrary, many believe in the case of man, that

in prehistoric time, when he was first differentiated from simian stock, he, wherever existing, was given over to unmixed promiscuity; that this was soon followed in many regions by some form of polygamy, and polyandry where women were scarce (rare); as promiscuity disappeared, and polygamy became far less prevalent, some mode of monogamy appeared, and this, at the present time is the form of marriage adopted by nearly all civilized races. In other words these various customs have shaded into each other, —that is, in the main, promiscuity for the wild, prehistoric people; followed by polygamy for ancient times, with monogamy now ever on the increase. Still we must bear well in mind that we have polygamy now openly followed in the United States, and some of the lowest existing races of the world are monogamous.

These facts are thus briefly presented in that we may contrast them with what occurs in the class of birds. Theoretically, in one way, the lowest forms of existing birds should in their mating be given over to promiscuity; those higher in the scale should be polygamous; and, finally the most specialized types, as the Passeres, be monogamous. This, however, is by no means the case, and agreeing with our own species, some of the existing groups of birds most nearly related to extinct types, closely associated with reptilian stock, are strictly monogamous, while others perhaps, are promiscuous (no birds being polyandrous); and still others affording examples of polygamy. So it is too, higher up in the scale, just as it is, as before remarked, with the human species.

Tracing birds back through geologic time as best we can by means of the material at hand there is no question but what in their morphology they approached nearer and nearer the archaic types of reptiles. Avian and reptilian osteology especially emphasizes this fact, and it is well known that some of the existing families of birds from various parts of the world exhibit in their skeletons characters that were more or less common to the entire class Aves as represented in that age of the Earth's history when birds had first become more or less differentiated from their reptilian ancestry. This by no means implies, however, that the present day existing families of birds, in the osseous systems of which still are to be met with those more pronounced evidences (in the

way of characters) of their reptilian relationships, are distinctly more closely allied upon that account. Many taxonomers, however, have thought so; and have endeavored to show that all existing true ostrich forms, the Kiwis, and tinanous are a sort of modern affined struthious types. On the other hand a Kiwi (Apteryx) is no nearer an ostrich, and an ostrich to a tinamou, than a limpkin (Aramus) is to a bustard, and a bustard (Otis) to a quail (Colinus). Therefore it need not surprise us, in view of all that has been set forth above, that the various modes of mating of any of these birds should be entirely different, or that these modes should fail to throw any light upon their affinities. For a moment then let us see what some authors have to say in regard to the mating of ostriches and their allies.

Professor Newton, quoting Lichtenstein, says: "Though sometimes assembling with Zebras or with some of the larger antelopes, ostrichs commonly, and especially in the breeding season, live in companies of not more than four or five, one of which is a cock and the rest are hens. All the latter lay their eggs in one and the same nest, a shallow pit scraped out by their feet, with the earth heaped around to form a kind of wall against which the outermost circle of eggs rest. As soon as ten or a dozen eggs are laid, the cock begins to brood, always taking his place on them at nightfall surrounded by his wives, while by day they relieve one another, more it would seem to guard their common treasure from jackals and small beasts-of-prey than directly to forward the process of hatching, for that is often left wholly to the sun."[1] From this it is clear that the African Ostrich is a polygamous bird by nature.

The Rhea or South American ostrich (*Rhea darwini, americana*, etc.) is also undoubtedly polygamous in nature, while the emeus of Australia are said to be monogamous, though neither Newton or Pycraft[2] say anything on this point. Neither do they give us any information on this point in regard to the cassowaries, birds

[1] Newton, Alfred. *A. Dictionary of Birds.* Part III, Art. "Ostrich," pp. 664–665. 1894, quoted from M. H. K. Lichtenstein, *Reise im südlichen Africa*, ii, pp. 42–45 (Berlin: 1812.). The fact that the sun assists in hatching the eggs of the African ostrich is disputed, but it is doubtless true. Captive ostriches are usually enforced to lead a life of obligatory monogamy.

[2] Pycraft, W. P. *The Living Animals of the World.* Vol. II, p. 394, London (no date).

more or less closely allied to the emeus. Indeed, I am unable to state whether a cassowary is, by nature, polygamous or monogamous. Their eggs have been described but apparently not their mating habits. None of the above-named writers describe the breeding habits of the kiwis (*Apteryx oweni*, *mantelli* and *australis*) and I am unable from personal observation to state whether they are by habit monogamous or polygamous (see Sir Walter Buller, Newton, Pycraft, and other writers). These curious birds, now being rapidly exterminated, are probably monogamous, as Dr. Claus says of them, "The kiwis are nocturnal birds, which by day remain concealed in holes in the earth and go out at night to seek their food. They feed on insect-larvæ and worms, live in pairs, and at the breeding time, which seems to come twice in the year, they lay, in holes scraped in the earth, a strikingly large egg, which, according to some, is incubated by the female, and according to others by the male and female in turn." [1]

So far as I have been able to ascertain, the tinamous (Cryptoridæ) are monogamous birds, while they associate together in flocks during those times of the year when they are not breeding. Newton does not mention this in the "Dictionary," and at this writing I do not happen to have Bartlett's paper at hand (P. Z. S. 1868, p. 115, pl. xii). In fact there are but very few good accounts of the breeding habits of these very interesting birds. Their wonderfully beautiful eggs are well-known to naturalists,

All water birds of the main groups appear to be monogamous in the matter of their mating. There appear to be no exceptions to this rule to be met with among the several suborders of the Pygopodes, Impennes, Tubinares, Steganopodes, Longipennes, Alcæ, and the Chionides. As we know, these groups contain the divers, the penguins, the petrels, the pelicans and various allies, the gulls, and the auk tribe. Nearly all these forms are low in the scale, and in all we meet with near relatives among birds that are extinct and certain fossil types. Yet, as I say, they are all monogamous so far as my knowledge carries me. Passing next to the great limicoline assemblage (Limicolæ), it is to be observed that it contains, with their numerous allies, the

[1] Claus, Dr. C. Elementary Text-book of Zoology. Translated by Sedgwick and Heathcote. Pt. ii, p. 272, 1885.

plovers, the turnstones, the surf birds, the snipes, the phalaropes, the avocets, and the jaçanas, the entire host being monogamous by habit, with but one famous exception, namely, the truly polygamous ruff (*Machetes pugnax*). The peculiar habits of courtship and breeding practiced by this species have been well-described by a number of continental naturalists.[1] Among the Limicolæ there appears to be, among existing birds, but one other species suspected of being a polygamist, and this is the double or solitary snipe (*Scolopax major*) of Europe. Newton does not mention the fact in the "Dictionary," but Darwin remarks in "The Descent of Man," that "some of the above birds,— the black-cock, capercailzie, pheasant-grouse, ruff, solitary snipe, and perhaps others, are, as is believed, polygamists." (p. 406.) From all that I can gather, it would seem that the question has not yet been decided. Coming to the Cursoræ, the group contains but few species that I know of, that have been suspected of being polygamists and among these is the great bustard (*Otis tarda*),— and with it most of the evidence seems rather to point to the fact, that such is the case. Whether any other representatives of this somewhat numerous group (Europe, Africa, Asia, and Australia) are polygamous by habit, I am unable at present to say. However, the birds called 'floricans' of India, closely allied species to the bustards, are reported as practising polygamy. There seem to be two known species of these, — the Bengal (*Sypheotides bengalensis*) and the lesser florican (*S. aurita*). During pairing season the two sexes live apart in groups, and in mating come together, and "when a male wishes to attract a temporary partner, he does so by going through an elaborate series of performances."[2] It is possible that all the true bustards possess strong inclinations in this direction, even if they are not actually polygamists. Not so, however, with the stone curlew (*Œ. crepitans*) a species I have relegated to the Cursoræ, although, I by no means consider it to be very closely allied to the Otididæ.[3]

[1] See A. Newton, art. "Ruff." Dict. Birds, Darwin, "The Descent of Man," p. 219, Montagu (*Suppl. Orn. Dict.* 1813); Pennant, Daniel, Graves, Collett, Lubbock, Southwell, Stevenson and others.

[2] Lydekker, R. *The Royal Nat. Hist.* p. 458.

[3] Shufeldt, R. W. "An Arrangement of the Families and the Higher Groups of Birds." *The Amer. Nat.*, Vol. **38**, Nov., Dec., 1904, pp. 833–857.

Monogamous matings seem to be the rule with all the cranes and rails, with their allies, near and remote.[1]

Probably no group of birds in the world's entire avifauna have been more closely studied or had more written about them than the great gallinaceous group of fowls, including among them not a few other such familiar birds as the turkeys, the guinea fowls, quails, partridges, grouse, pheasants, and their various allies, near and remote. Good and sufficient reasons there are for this, as a very large number of them are, and have been, long domesticated, as the chickens and turkeys. All of them constitute game in every part of the world; while many of them are kept in zoological gardens and private preserves, as the pheasants and others. None of the Galliformes, I believe, are polyandrous, though many of the families are curiously divided up between polygamy and monogamy, some being strong adherents of the first-named practice, while others, under no circumstances, depart from the latter mode of mating.

Captivity sometimes influences these habits, and birds that are polygamous in nature become monogamous when their domestication is undertaken, and *vice versa*. Beautiful accounts have been given us by different naturalists of the often extraordinary courtships to be seen in the case of many of the representatives of this suborder of birds, while in other cases there habits are still quite unknown to science. Whether the Hemipodes or button quails (Hemipodidæ) are polygamous or not, I cannot at this writing say, but it is a well known fact that with them the females are brighter plumaged while the males, resembling the subadult specimens, perform all the duties of incubation. All this is

[1] *Loc. cit.* pp. 851, 852. It is here intended to include the supersuborders Gruiformes and Ralliformes. Curious and puzzling forms of birds occur in the first assemblage (Grues) such as the trumpeters (Psophia), the seriema (Cariama), the sun-bitterns (Eurypyga), the kagu (Rhinochetus), and the Mesitidæ of Madagascar. Although many of these have been long known to ornithologists, and much written about them, it is by no means certain that they are all monogamous species in nature, as I believe the finfoot (Heliornis) among the Ralliformes to be. Several of those named have been kept in zoölogical gardens, where they have reared their young, but a bird may be monogamous in captivity and polygamous in nature. Both the sun-bitterns and the kagu practice a show-off, but it does not appear to be confined to the breeding season or to their modes of courtship.

reversed in the little common quail of the old world (*Corturnix communis*), a well-known polygamous species, where the males are both larger and handsomer than the females.

As to the Megapodes or brush turkeys (Megapodidæ) of the East Indies and Australia, none of the writers at hand state whether they are polygamous or otherwise.

The habits of these birds are pretty well known, especially their burying their eggs in immense mounds which they build, or concealing them in sand-holes and burrows, in either situation they hatch out by the sun and the heat of the fermenting vegetable matter in the mounds. The young fly an hour after they are hatched. Wallace describes several species of them in his "Malay Archepelago," but does not state whether they are polygamous or not, and neither Newton or Pycraft have anything to say upon that point.[1]

Most ornithological writers lay it down as a rule that among the Gallinæ generally, where the cock bird is evidently larger than the hen and its plumage is remarkably conspicuous, the hen, being more or less plain in this particular, the species is polygamous, whereas, when the sexes are nearly alike in point of size, and but little difference in plumage, they are almost certain to be monogamous in their mating. There are, however, a few exceptions to this rule.

Personally, I have never studied the curassows and guans (*Cracidæ*) in their native haunts, and therefore cannot say, from my own experience, anything in regard to their mating habits. In this group, I take it, the curassows of South America are probably monogamous, as is likewise our Chachalaca (*Ortalis v. maccalli*), though in the case of the latter species, where the sexes are nearly alike, few American ornithologists describe its courtship and mating, notably Bendire, Coues, Ridgway (Manual), and others, while continental writers rarely refer to it. Neither Audubon or Wilson ever saw the bird.

Finally, the suborder Gallinæ is seen to contain five very ele-

[1] *Loc. cit.* Art. "Megapode" Pt. ii, p. 539, and Pycraft, "Living Animals of the World" Lond. p. 411. One writer states that several hen megapodes may bury their eggs in the same mound, but does not say whether the birds all belonged to the harem of one male.

gant families of birds, representatives of which, in more or fewer species, are found in all parts of the world. These are the pheasants (Phasianidæ), the grouse (Tetraonidæ), the American Partridges (Odontophoridæ), the Guinea fowl (Numididæ), and the Turkeys (Meleagridæ). Great is the wealth of species in the most of these several families, and while some of them are polygamous, others are strictly monogamous, and the habits of any of them may be changed through domestication, and they sometimes infringe upon, or even break, some of the rules given in foregoing paragraphs. Included in their ranks are all of our common domesticated gallinaceous fowl, and occasionally the habits of some of these are very remarkable.

Very much do I regret that I cannot give more space to this group as it is both an interesting as well as an important one; moreover, authors are by no means unanimous in their opinions in regard to the modes of mating, and in the case of some species we have apparently no data at all. Considerable part of the literature has been carefully looked up by me. No one seems to question but what such species as the capercailie and black grouse of northern Europe are polygamous. Pheasants and their near allies are likewise so, and I believe the famous Argus pheasant is, but in this I may be wrong. The wild turkeys of North America are also polygamists, though it is said that the old males generally have a favorite hen,while the other females he favors are but his concubines. Peacocks are polygamous but the various species of Guinea fowl are eminently monogamous. When the latter are domesticated, however, as vast numbers of them are, I have personally known a male Guinea fowl to take charge of six or seven hens, and the latter would all lay the usual number of eggs and bring forth their young. From all I can gather, it has been found that all the species of ptarmigan wherever they occur are monogamous. This seems to be the case too, with the birds we call quail (American partridges: Odontophoridæ), though I am not so sure about the species of the genus Cyrtonyx. The common partridge of Europe is monogamous, as are the majority of our typical grouse (Canada, dusky, Franklin's and others), the sage cock, however, is polygamous (Centrocercus).

Audubon, whose life-histories of our game birds are so thorough-

ly unsatisfactory, in his account of the mating of the pinnated grouse (Tympanuchus) gives one the impression that he believes the bird to be monogamous, while in his account of the ruffed grouse (Bonasa) he states in referring to the latter species, that "The males have the liberty of promiscuous concubinage, although not to such an extent as those of the pinnated grouse."[1] Bendire, on the other hand when describing the habits of the ruffed grouse (*B. umbellus*) says, "By many persons the ruffed grouse is considered polygamous, and while I can not actually disprove that assertion, I doubt it very much."[2]

Again authors are at variance in their opinions with respect to the several species of the sharp-tailed grouse (Pediocætes) and E. T. Seton, quoted by Bendire, says of the prairie sharp-tailed grouse in describing the remarkable dance of the males, "Its erratic character can hardly be questioned.... The whole affair bears a close resemblance to the manœuvring of the European ruff, and from this and other reasons I am inclined to suspect the sharp-tail of polygamy."[3]

The curious hoatzin of tropical South America (Opisthocomus) in a way related to the Gallinæ, is said to be polygamous, but as yet we stand quite in ignorance of some of the habits of this interesting form in nature.

Sand-grouse (Syrrhaptes) and their kin I believe are monogamous, and I do not at this writing recall any species of wild pigeon (Columbiformes) that has any other form of mating in the breeding

[1] Audubon, J. J. Birds of America, Vol. V, pp. 78 and 93–105, 1839.

[2] Bendire, Chas. E. Life Hists. Amer. Birds, p. 61. In the same work (p. 90), and quoting Judge John Dean Caton, he evidently believes the pinnated grouse to be monogamous, when it is stated that "It is toward the latter part of the love season that the fighting takes place among the cocks, probably by two who have fallen in love with the same sweetheart, whose modesty prevents her from selecting between them."

[3] *Loc. cit.* p. 105. I am of the opinion that this question has by no means been definitely settled yet, except perhaps in the case of the ruffed grouse which has been kept and reared in confinement by Mr. C. F. Hodge who says "The cocks of the ruffed grouse are evidently polygamous. I observed the "wild" cock mate with the two "wild" hens. The hens, however, permitted mating but once, and after mating, if left together, the cock will pick the hen to death." (Rep. of the Comm. on Fisheries and Game. Dec. 31, 1905 [Mass.] Pub. Doc. No. 25, pp. 66, 67.

season, though to me pigeons are by no means always so. Those birds known as screamers (Palamedæ) also appear to be monogamous, and I believe the entire swan, goose and duck tribe (Anseriformes) are,— at least in nature, although there may be exceptions to this that I either do not recall for the moment, or have not come to my notice. When domesticated, however, ducks may become highly polygamous, and it is a well-known fact that in this state it is not difficult to cross various species and rear interesting hybrids. Cases of this character are reported by Darwin, who states with respect to birds that "In several groups I have not been able to discover whether the species are polygamous or monogamous."[1]

"Very peculiar fancies," says Letourneau, "sometimes arise in the brains of certain birds. Thus we see birds of distinct species pairing, and this even in a wild state. These illegitimate unions have been observed between geese and barnacle geese, and between black grouse and pheasants," and further, when quoting Hewitt from Darwin as to how a common tame mallard duck threw over the male of own species and deliberately courted a male pintail that had been placed in the water with her, mated, and would have nothing further to do with the mallard, he says "that conjugal fidelity does not always resist a strong impression arising from a chance encounter; that novelty has a disturbing effect; and, finally, that indifference and coldness can rarely hold out against the persistent advances of one who loves ardently enough not to yield to discouragement. Dante has already made this last reflection in his celebrated line —

'Amor ch'a null' amato amar perdona.'

To quote Dante *à propos* of the illicit amours of a pintail and a wild duck may shock the learned, but the aptness of the quotation proves once more the essential identity of the animal and human organisms."[2]

Polygamy is not practiced, so far as I am aware, by any of the flamingoes (Phœnicopteri), or representatives of the crane-stork assemblage (Herodiones), or the diurnal Raptores including all the vultures (Accipitres), or the parrot group (Psittaci), or

[1] *Loc. cit.* pp. 219, 218.

[2] Letourneau Ch. *The Evolution of Marriage.* London. 1900. pp. 28, 29.

the owls (Striges), the Caprimulgine forms (Caprimulgiformes). None of the Coraciæ (rollers, etc.) I believe are polygamous, or the kingfishers (Halcyoniformes), or the Bucerotes, or representatives of such suborders as the Upupæ, the Meropes, the Momoti, or the Todi, but when we come to the humming-birds (Trochili) some authorities still seem to be in doubt, and no less a distinguished ornithologist than Mr. Salvin told Darwin that he was "led to believe that humming-birds are polygamous," [1] but, the present writer by no means entertains any such an opinion.

Comparatively speaking, very little is known of the courtships and matings of the Jacamariformes (jacamars and puff-birds) and the Trogoniformes (trogons), but I believe none of them to be polygamous in their habits, although if found to be so it would in no way surprise me, on account of the relations of the latter to the cuckoos.

When I say this I do not mean to imply that any of the cuckoos are strictly polygamous, and no writer seems to be perfectly certain on that point. What the mating habits of the touracos (Musophagidæ) is like, I am, at this writing unable to say, but it is very interesting and important for us to know. Those who have had opportunity to study them have, as in so many instances in ornithological history, overlooked all this. The literature upon the nidification of the cuckoos (Cuculidæ) would make many volumes so it is quite unnecessary to dwell upon it here. Their depositing their eggs in the nest of other birds is simply parasitism, and for all I know to the contrary, the European cuckoo may be the veriest polygamist in the world's avifauna, and the same is true of others of his kin that follow the same practice. It is not likely that these birds are monogamous, it being far more probable that they follow some form of promiscuity, or where there is a scarcity of males, even polyandry? All these remarks likewise apply to our cowbirds (Molothrus) of the Passeriformes, birds which I am quite sure from personal observation may be either polygamous, monogamous, promiscuous, or have recourse to concubinage, or perchance in some instances, may even be polyandrous, though

[1] *Loc. cit.* p. 219. I have never seen any evidence of this in an common eastern form, the ruby-throat, nor in any of those I have had the opportunity to study in the west.

it is only through the force of circumstances that birds are ever the latter, as some seem to contend.

Some of the breeding habits of Cuckoos in various parts of the world are truly remarkable, as witness those of this country (Crotophaga, Geococcyx and Coccyzus). It would appear, from what we know of its habits, that our Anis may be strictly polygamous (Crotophaga), inasmuch as several females of this species all lay their eggs in the same nest,— but even so, they may be the mates of different males.

There are some wonderfully interesting questions that arise, when we come to study the courtships, mating, and nidification of the cuckoos, cuckoo-like birds, and the cowbirds, and especially when we apply this knowledge, in a comparative way, with the customs followed by our own species. Space, or rather its limitations, will not admit of my discussing any such matter here. Furthermore, the author is at present engaged upon a volume that will take fully into considerations all such questions, and where sufficient data is available, endeavor to throw some light upon their significance. Right here I may say, however, that the reader cannot be too strongly commended to read in the present connection all that Darwin has to say with respect to birds in *The Descent of Man* (pp. 219–221 and 358–499); also Letourneau on the *Evolution of Marriage.*

Returning to the cuckoos for a moment, I find Dr. R. Bowdler Sharp has said of the common European species (*C. canorus*), "There can scarcely be any doubt that the number of males considerably exceeds that of the females and some naturalists not only speak of the species as polyandrous but declare that the female bird does all the courting." They are said to lay twenty eggs in one season.[1]

Other than those referred to above, I know of few other birds in the world that are given to polygamy, though I expect the breeding habits of some of them are wonderfully interesting, not to say curious. Little or no information is before me on such subjects with respect to some of the following suborders, namely the Pamprodactylæ, Capitones, Rhamphastides, Indicatores, Piciformes,

[1] Cuckoos, Royal Nat. Hist. Lond., R. Lydekker, Editor. This work contains some excellent general accounts of birds and their habits.

Cypseliformes, and the Eurylæmiformes, although I know of no species or family among these several groups that are not strictly monogamous by nature, while they may differ very widely in their habits of nidification. Unfortunately, we still know very little about the life-histories of the lyre-birds of Australia (Menura), and some naturalists believe them to be polygamous. Again, Darwin quoting Lesson says "that birds of paradise, so remarkable for their sexual differences, are polygamous, but Mr. Wallace doubts whether he had sufficient evidence."[1]

In closing this article it is well to note that what I have set forth in it has probably long been known to the majority of general and observing naturalists of each generation, but not so to the average reading public, and, unfortunately not to a great many people to whom the knowledge would be of considerable interest if not of positive value.

It is clearly shown that birds, as a Class among Vertebrates, in nature may, in mating, be polygamists, monogamists, or under certain conditions given to practices simulating polyandry, or, as some claim, actual polyandry. At present we have no knowledge of the origin, causes, and in the majority of cases, the needs of these various habits. The radical changes that birds, in most instances make in these particulars under domestication are often more easily explained. That the satisfaction of the sexual instinct and the equally imperative demand, on the part of nature, that the species be perpetuated, if possible, is the essential part of the explanation, there can be no question. No one in any way familiar with general biology, and the past and present life histories of animals on this planet, would for an instant claim that any of these mating habits in birds were of a criminal nature. It is only the

[1] *Loc. cit.* p. 219. The fact of the matter is the so-called birds of paradise differ widely among themselves in structure appearance and in habits; so it may be that some of them are polygamists and others monogamists,— and this is possibly, indeed, probably the case. On the same page as quoted above, Darwin remarks that the male widow-bird, remarkable for his caudal plumes, certainly seems to be a polygamist," and Lydekker in the *Royal Natural History*, quoting Mr. Bowker (p. 366 of Vol. iii), says of the paradise whydahs (Vidua), an African genus of birds the same to which Darwin refers, that one male not unusually mates with at least fifteen females. This species is frequently seen in captivity.

ignorant, the superstitious and narrow-minded who entertain such views. We have plenty of storks, black grouse, and even European cuckoos and American cow-birds among our own species, but the significance of all this, and its biological importance to our kind, I shall endeavor to point out in another connection later on.

ON THE WOOD RAILS, GENUS ARAMIDES, OCCURRING NORTH OF PANAMA

OUTRAM BANGS

For many years I have been gathering all specimens I could of the splendid, great Wood Rails of the genus Aramides with the hope of some day monographing the group. Unfortunately I have as yet been unable to bring together sufficient material from South America to attempt to include in review the forms of that country. I now have, however, a complete set of the species and subspecies of Middle America from Panama north to the northern limit of the genus in southern Mexico. A critical study of this material together with a number of skins kindly lent me by the United States National Museum, the American Museum of Natural History, and the Bureau of Biological Survey of Washington, which include the types of *Aramides plumbeicollis* Zeledon, *A. axillaris* Lawr. and *A. albiventris* Lawr. has induced me to publish now a short synopsis of the forms of Aramides occurring north of Panama.

My views expressed in the following pages will be found to differ a little from those of recent authors, such as Sharpe in Vol. XXIII Catalogue of Birds in British Museum 1894 and Biologia Centrali-Americana, Aves, 3, 1897–1904, and I describe as new one form from Mexico, allowing to the region here treated three species and two additional subspecies.

In all species of Aramides the sexes are alike in color and there are but slight individual or seasonal differences, apart from those caused of the wholly mechanical processes of fading and wear. Some species have a juvenile plumage, still worn when the bird is nearly full grown, that is quite different in color from the livery of the adults — *A. axillaris* and its allies. Other species, apparently (I have seen but one young individual of *A. albiventris plumbeicollis*, and none at all of the other subspecies of *albiventris* or of *A. cajanea*) do not have a young plumage that is very distinctly different in color from that of the adults.

If the specimens examined by me are correctly sexed, there is also no average difference in size between the sexes in any of the species or subspecies. All, however, vary much in size individually, in fact to a degree I am wholly unable to account for.

Key to the Species and Subspecies of Aramides occurring north of Panama

A. Sexes alike in color.

1. Under wing-coverts banded black and white
A. axillaris Lawr.

1. Under wing-coverts banded black and cinnamon-rufous or hazel . . . . . 2.

2. Back of head, between gray forehead and gray neck not distinctly chestnut, but grayish-brown or brownish-gray
A. cajanea (Müll.).

2. Back of head distinctly chestnut . . . . . 3.

3. Back concolor, olive . . . . . 4.

3. Back not concolor; olivaceous-tawny anteriorly, olive posteriorly . . . *A. albiventris plumbeicollis* (Zeledon).

4. General color paler; light colored crescent around the black belly patch, very wide, white
A. albiventris albiventris Lawr.

4. General color darker; light colored crescent around the black belly patch, narrow, fulvous
A. albiventris mexicanus nobis.

Aramides axillaris Lawrence

Aramides axillaris Lawr. Proc. Phil. Acad. p. 107, 1863. Sharpe Cat. Birds Br. Mus. **23**, p. 56, 1894. Biol. Cent. Am., Aves vol. **3**, p. 318, pl. LXXVII, 1897–1904.

Type Locality. Barranquilla, Colombia. Type, now No. 45655, American Museum of Nat. Hist., New York, examined.

Geographic Distribution. British Guiana, Trinidad, and northward through Venezuela and Colombia to southern Mexico.

It has been supposed that there was a break in the range of this species and that it did not occur in southern Central America south of Honduras. There is, however, in the Underwood collection, lately purchased by John E. Thayer Esq., a young example

of *A. axillaris*, nearly full grown but with the under parts still brownish slate-color, from Costa Rica. Unfortunately the label bears nothing more definite than "Costa Rica." While certainly very rare in southern Central America, I still believe *A. axillaris* has a continuous range. It is a rare species in northern South America, and seems to be nowhere so plentiful as in the region lying between southern Mexico and Honduras. At all events I can detect no difference between northern and southern specimens.

CHARACTERS. Size small; bill short; under wing-coverts banded blackish and white; neck and head, except throat, rufous-chestnut; a conspicuous gray patch occupying upper interscapular region and lower hind neck.

COLOR. Adult plumage. Throat white; head, neck and breast bright rufous-chestnut; upper interscapular region and lower hind neck gray (about slate gray); back, wing-coverts and wings except primaries and secondaries, olive; rump brownish black; tail and upper and under tail-coverts, black; belly and thighs slate-color; primaries hazel; secondaries also hazel but duller, more dusky toward tips; under wing coverts and axillars banded black and white; bend of wing and tips of axillars usually banded black and hazel; "tarsus vermilion; beak green, basal portion yellow; iris brown."[1]

Young differ from adults in having the neck and under parts dull slate-color, and the characteristic gray patch on lower hind neck and upper back less distinct though still evident.

MEASUREMENTS.

No.	*Sex & Age*	*Locality.*	*Wing.*	*Tail.*	*Tarsus.*	*Culmen.*
45655[2]	Type —	Colombia, Barranquilla.	171.	60.	57.5	44.
6159[3]	♂ ad.	Colombia, Chirua.	166.	57.	57.	43.
167364[4]	♂ ad.	Yucatan, Mujeres Isl.	165.	58.	54.	41.
141535	♂ ad.	Mexico, Guerreo, Acapulco.	168.	54.	56.	43.
157363	♂ ad.	Mexico, Tepic, San Blas.	169.	60.	60.	45.
50871[5]	♂ yg. ad.	" " "	166.	—	57.	42.5
52844	——	Mexico, Mazatlan.	170.	58.5	54.5	42 5

[1] From notes made from fresh specimen by W. W. Brown Jr.
[2] Coll. of American Museum of Nat. Hist., New York.
[3] Coll. of E. A. & O. Bangs, Boston.
[4] Coll. of Bureau of Biological Survey, Washington.
[5] Coll. of U. S. National Museum, Washington.

No.	Sex & Age	Locality.	Wing.	Tail.	Tarsus.	Culmen.
105554	yg.	British Guiana.	168.	53.	51.	39.
16375[1]	yg.	Costa Rica.	156.	50.	51.	40.5

REMARKS. *A. axillaris* is a small species with a short bill, related to *A. mangle* (Spix) of Brazil of which it is the northern representative. Judged by the few specimens I have been able to examine I should think the two were specifically distinct.

A. axillaris is very different from any species occurring in the same region with it, being at once distinguished by its small size, black and white under wing-coverts and red-brown neck. It does not appear to be subject to any geographic variation — southern and northern examples being, so far as I can see, quite alike.

ARAMIDES CAJANEA (Müller).

Fulica cajanea Müll., Syst. Nat. Suppl., p. 119, 1776, based on Daubent. Pl. Eul. pl. 352.

Rallus chiricote Vieill., N. Dict. d' Hist. Nat., **28**, p. 551, 1789.

Aramides cayanea Sharpe, Cat. Birds Br. Mus. Vol. **23**, pp. 57–58, 1894.

Aramides cayanea subsp. A. *Aramides chiricote* Sharpe, Cat. Birds Br. Mus. Vol. **23**, pp. 58–59, 1894.

Aramides chiricote Biol. Cent. Am. Aves, Vol. **3**, p. 318, 1897–1904.

TYPE LOCALITY: Cayenne.

Geographic Distribution: Tropical America in general from northern Brazil north through Panama and Chiriqui to the Pacific slope of Costa Rica.

CHARACTERS: Size large (in point of size *A. cajanea* and its allies occupy an intermediate position in the genus, being much larger than *A. axillaris* and allied species, but inferior to the gigantic *A. ypacaha* (Vieill.) of southern South America); bill long; under wing-coverts banded blackish and hazel; neck and head gray, duller, browner on occiput; back concolor, olive; breast, concolor bright, deep, reddish tawny.

COLOR: Throat dull grayish white; rest of head and neck gray (nearest slate-gray) this color sometimes extending a little

[1] Coll. of E. A. & O. Bangs, Boston.

onto mantle, darkest on forehead and palest on cheeks, the occiput darker, duller, often brownish — grayish-brown, brownish-gray or grayish-olive; back and wings, except primaries and secondaries greenish-olive; primaries and secondaries hazel, darker, dusky olive toward tips, the outer secondaries olive on outer edges, and inner secondaries mostly olive; rump black, often suffused posteriorly with deep reddish olive; upper tail coverts and tail black; breast deep reddish tawny, varying slightly in tone (with season or age?), sometimes toward hazel sometimes toward orange-rufous; belly and under tail coverts black; thighs slate color; under wing coverts and axillars banded black and hazel; "tarsus poppy-red; terminal part of bill green, basal part yellow; obital ring red; iris red, *soon after death changing to brown*."[1]

MEASUREMENTS.

No.	*Sex & Age.*	*Locality.*	*Wing.*	*Tail.*	*Tarsus.*	*Culmen.*
11398[2]	—	Brazil, Santarem	180.	56.5	69.	51.
121110[3]	♀ ad.	Brazil, Diamantina	172.	64.	68.5	50.
15408	—	Brazil.	168.	58.	68.	52.5
16536	—	"	185.	70.	68.	57.
9942[2]	♀ ad.	Surinam, Paramaribo.	176.	61.	70.	57.
9943	♀ ad.	" "	168.	58.	68.	52.
17940[3]	—	Darien, Atrata.	177.	—	69.	—
148191	—	Panama.	175.	63.	71.	52.
7060[2]	♂ ad.	Panama, Loma del Leon.	173.	65.	69.	55.
7650	♀ ad.	Chiriqui, Divala.	177.	60.	72.	53.5
7649	♂ ad.	" "	185.	61.	71.	56.5
40386[3]	—	Chiriqui, David.	176.	60.	65.	54.
40392	—	" "	172.	66.	72.	55.5
132265	♂ ad.	Costa Rica.	190.	65.	71.	54.
64997	—	Costa Rica, Talamanca Dist.	182.	66.	68.	57.
64998	—	" "	184.	58.	72.	54.
67900	—	" "	175.	57.	69.	54.5
67905	—	" "	189.	54.	69.	50.5
16373[2]	♀ ad.	Costa Rica, Pozo Azul.	184.	59.	71.	53.5
16374	♂ ad.	" "	180.	63.	72.	57.
14297	♀ ad.	Panama, San Miguel Isl.	163.	58.5	67.5	52.
14298	♀ ad.	" "	170.	64.	66.	52.
14299	♂ ad.	" "	165.	59.	67.	52.
40343[4]	♂ ad.	" "	169.	—	67.	53.

[1] Notes made from freshly killed examples by W. W. Brown, Jr.
[2] Coll. of E. A. and O. Bangs.
[3] Coll. of United States National Museum.
[4] Coll. of Museum of Comparative Zoology.

Remarks. After very careful comparison of a large number of specimens I fail altogether to make out a subspecies, *chiricote*. I can find no constant differences whatever between skins from Brazil and Surinam on the one hand and the most northern examples from Chiriqui and Costa Rica on the other. Indeed Sharpe in Catalogue of Birds in the British Museum (Vol. **23**, pp. 57–59) does not assign any well defined geographic distribution to the two subspecies he recognizes. The patch of a duller color on the occiput varies considerably in shade — with season I think, that is with the condition of the plumage, whether fresh or much worn. Different examples from Panama and Costa Rica differ quite as much in respect to the shade of color and distinctness of this marking as do any two that can be picked out from the northern and southern parts of the range of the species.

Inhabiting the Pearl Islands in the Bay of Panama is a slightly paler and slightly smaller race of this rail. The four examples taken there by Mr. Brown cannot quite be matched by continental specimens, but the differences are too slight and in this genus of two unimportant a nature to base a subspecies upon.

There appears, however, to be in Brazil a well marked subspecies, the exact range of which I am through want of sufficient material unable to define. Skin "f" of Sharpe's list in Catalogue of Birds, belongs to this form (see footnote, p. 58) and there is one skin in the National Museum, No. 24124 from (St. Catharines ?) Brazil collected by Lemuel Wells, that appears to agree exactly with Sharpe's Rio de Boraxudo specimen, differing from *A. cajanea* in being mostly gray above, the gray of the upper neck pervading the entire mantle, the wing coverts alone being olive and these paler and decidedly more grayish olive than in *A. cajanea*; the rufous color of under parts, as pointed out by Sharpe in his specimen too, is also paler. This bird is not *Gallinula ruficeps* Spix, which, judged by the plate, is true *A. cajanea*, and undoubtedly represents a valid form.

Another peculiar individual is a very old skin in the National Museum, no. 15407, labeled "Buenos Ayres, J. K. Townsend ♂." In color this example agrees with true *A. cajanea* except in having the rump nearly wholly dark reddish olive. It is, however, very much larger with proportionally shorter tarsus and bill, the wings,

considerably worn at that, measuring, 200, tail 86, tarsus 73, culmen 55. It may represent still another subspecies.

Thus while in the northern part of its range from northern Brazil north, this rail does not vary to any extent with geographic areas, there seem to be in southern South America several geographic forms.

Aramides cajanea is another very distinct species, nearly allied only to *A. albiventris* Lawr. From that bird it can always be distinguished by its shorter, thicker bill, and duller color of the occipital region, which in *A. albiventris* is always bright chestnut.

Aramides albiventris albiventris Lawr.

Aramides albiventris Lawr. Proc. Phila. Acad., p. 234, 1867.

Aramides cayanea, subsp. B. *Aramides albiventris* Sharpe, Cat. Birds. Br. Mus. Vol. **23**, 1894, pp. 59–60.

Aramides albiventris Biol. Cent. Am., Aves, Vol. 3, p. 319, 1897–1904.

Type Locality; British Honduras, Type, now 45656, American Museum of Natural History, examined.

Geographic Distribution: British Honduras and Yucatan, and parts of Guatemala. Exact limits of range not known.

Characters: About the size of *A. cajanea* or slightly larger; bill longer and more slender than in that species; all the colors pale; a large, conspicuous patch of bright chestnut extending from between eyes over occiput to upper surface of neck; white throat patch large, extending well down neck; black of belly surrounded by a wide crescent shaped marking of white; under wing coverts banded black and pale hazel.

Color: Throat dull white, this color extending well down under surface of neck; on the occiput, extending backward to upper neck and forward to between eyes, a conspicuous patch of chestnut; rest of neck and head gray (about Gray No. 6 of Ridgway); back pale greenish olive; scapulars and sometimes outer interscapulars as well ochraceous-rufous more or less mixed with olive, this marking usually very conspicuous, though never forming a complete mantle across back as in the southern subspecies *plumbeicollis*; primaries and secondaries, light, bright hazel;

rump black, somewhat dusky olive anteriorly; upper tail coverts and tail black; breast pale tawny-ochraceous becoming ochraceous-buff posteriorly; a wide crescent shaped marking of white or sometimes cream-buff, around upper part of black belly patch; belly and under tail coverts black; thighs slate color; under wing coverts and axillars banded black and pale hazel, the tips of the feathers sometimes buff.

Measurements

No.	*Sex & Age.*	*Locality.*	*Wing.*	*Tail.*	*Tarsus.*	*Culmen.*
45656[1]	Type	British Honduras.	186.	62.5	80.	63.5
——— [2]	—	Belize, British Honduras.	180.	65.	74.5	60.
130325	—	Yucatan	176.	57.	74.	60.5
130326	—	"	177.	59.	76.	64.
130327	—	"	177.	58.	80.	65.
148192	—	"	184.	62.	77.	—
15246[2]	♂ ad.	Yucatan, Rio Lagartos	177.	63.5	74.	62.5
33668[2]	—	Guatemala, Chiapam	187.	62.	78.	66.
42777	—	Central Guatemala	176.	58.	75.5	66.

Remarks. Typical *A. albiventris* occurs only, so far as I know, in the coast region of British Honduras and Yucatan, and in its very pale coloration parallels other bird forms of the same region such as the clapper rail, lately named *Rallus pallidus* by Nelson.

Two specimens from Guatemala I refer here, though they are intermediates, between *A. albiventris albiventris* and *A. albiventris mexicanus*, the one from central Guatemala being nearer to Yucatan and British Honduras examples, the other from Chiapam on the Pacific coast being more like the Mexican bird. To the northward true *A. albiventris* is replaced by a darker form with less distinct and more fulvous crescentic marking on the belly, that occupies southern Mexico and that I have named below as a new subspecies. Farther south in Central America *A. albiventris* is represented by a form — *A. plumbeicollis* — quite different in some details of coloration, and somewhat smaller, but still so like it in general that I have no hesitation in regarding the southern form as a subspecies rather than a segregate species.

[1] Coll. American Museum of Natural History.
[2] Coll. United States National Museum.
[3] Coll. E. A. and O. Bangs.

I find no indication of intergradation between *A. cajanea* and *A. albiventris* and must regard them as distinct species. The much longer more slender bill of *A. albiventris* and the conspicuous chestnut patch on the back of the head, always serve to distinguish it in all its subspecies from *A. cajanea*.

Aramides albiventris mexicanus sub. sp. nov.

Type: from Buena Vista, Vera Cruz, Mexico, adult ♂, no. 2281 Coll. of E. A. and O. Bangs. Collected June 4, 1901, by A. E. Colburn and P. W. Shufeldt.

Geographic Distribution: Southern Mexico, in States of Vera Cruz, Tabasco, Oaxaca and Chiapas, north to Hidalgo (one skin from Orizava no. 29231, U. S. Nat. Mus.) and on the coast at least to Tampico.

Characters: Very similar to true *A. albiventris*, but pale crescentic marking on belly, surrounding black belly patch much narrower and less distinct, strong buff in color, not white or cream buff; all the colors darker — gray of head and neck, greenish olive of back, and tawny of breast; much less suffused with ochraceous or tawny on scapulars and outer interscapulars though this marking is often indicated; throat less purely white, more grayish and this marking more confined, extending less onto under surface of neck.

Measurements

No.	*Sex & Age.*	*Locality.*	*Wing.*	*Tail.*	*Tarsus.*	*Culmen.*
2281[1]	Type ♀ ad.	Mexico, Vera Cruz, Buena Vista.	177.	54.	74.	64.
2280	♂ ad.	" " "	180.	56.5	76.	63.
141536[2]	♀ ad.	Mexico, Vera Cruz, Tlacotalpam.	179.	59.	74.	63.
141537	♂ ad.	" " "	185.	59.	73.	61.
141539	♀ ad.	" " "	173.	58.	77.	64.
58966[3]	—	Isthmus of Tehuantepec.	189.	60.	83.	73.
76990	—	"	185.	67.	78.	66.
29231	—	Mexico, Hidalgo, Orizava.	188.	64.	79.	67.
141541[2]	♀ ad.	Mexico, Oaxaca, Guichicovi.	182.	58.	73.	61.5
11012[1]	♀ ad.	Mexico, Tabasco	164.	60.	70.	62.
11013	♂ ad.	" "	184.	62.	80.	66.

[1] Coll. of E. A. and O. Bangs.
[2] Coll. of Bureau of Biological Survey, Washington.
[3] Coll. of U. S. National Museum.

REMARKS: *Aramides albiventris mexicanus* is the northern representative of this group of the genus, occupying the southern tier of states of the Republic of Mexico and southeastward passing gradually into true *A. albiventris* of Yucatan and British Honduras. Though well characterized subspecifically it is in general much like true *A. albiventris*. It can, however, always be told from that form by the characters pointed out above.

ARAMIDES ALBIVENTRIS PLUMBEICOLLIS (Zeledon)

Aramides plumbeicollis Zeledon Anales. Mus. Nac. Costa Rica, **1**, p. 131, 1887. Biol. Cent. Am. Aves, Vol. **3**, p. 320, 1897–1904.

TYPE LOCALITY: Jiménez, Costa Rica. Type now no. 113603, U. S. National Museum, examined.

GEOGRAPHIC DISTRIBUTION: Costa Rica, specimens examined from Jiménez, Carrillo, and Cariblanco de Sarapiqui, north at least to Segovia River, Honduras.

CHARACTERS: Similar to *A. albiventris mexicanus*, but slightly smaller; bill actually shorter, though relatively of about the same length; differing in color principally in having a complete mantle across upper back of olivaceous-tawny — the back thus bicolor, olivaceous — tawny anteriorly, greenish olive posteriorly; breast rather darker than in the other two subspecies more nearly as in *A. cajanea*; crescentic marking made by paler feathers around black belly patch, when present, narrow and buff in color (in two skins, one from Carrillo and one from Cariblanco de Sarapiqui this marking shows very distinctly; in the type and one other skin from type locality it is barely indicated).

MEASUREMENTS.

No.	*Sex & Age.*	*Locality.*	*Wing.*	*Tail.*	*Tarsus.*	*Culmen.*
113603[1]	♂ ad. Type	Costa Rica, Jiménez	173.	51.	74.	57.
115045	♀ ad.	" "	170.	53.	75.	—
16371[2]	♀ ad.	Costa Rica, Cariblanco de Sarapiqui.	172.	50.	75.	58.
16372	♀ ad.	Costa Rica, Carrillo.	175.	56.5	73.	61.
112254[1]	♂ yg.	Honduras, Segovia River.	173.5	58.	75.	53.

[1] Coll. of United States National Museum.
[2] Coll. of E. A. and O. Bangs.

Remarks: I feel confident that I am right in placing this bird among the subspecies of *A. albiventris*, rather than to allow it specific rank. In all essential points — the long slender bill and chestnut color of the occiput and crown it agrees with *A. albiventris albiventris* and *A. albiventris mexicanus*. The brown mantle strikes one at first as a very strong point of difference, but this is in reality only a difference of degree, many northern skins showing a very decided approach to it, though it is in them never quite complete all across the back as it invariably is in the Costa Rican bird. The southern form is also somewhat smaller and darker in color below than either of the other two races, but every indication, in my opinion, points to its being a representative geographic form — subspecies — of the *A. albiventris* type.

The specimen from Segovia River, Honduras, unquestionably belongs here, as first pointed out by Richmond (Proc. U. S. Nat. Mus. **16**, p. 528, 1894). It is young, and as it happens is the only young example of any of these rails, except *A. axillaris*, that I have seen. The feathers of the underparts, especially the belly, are more fluffy than in the adults and in color it differs in the belly (black in the adult plumage) being black only at the base of the feathers which are externally tipped and suffused with the tawny color of the breast and in the rump, also clothed in fluffy feathers, being decidedly paler and browner. Though badly shot in the back and neck with many feathers from these parts lacking, the complete mantle of olivaceous-tawny is plainly to be seen. The bill is not full grown and is very immature in appearance. Judging from this skin it appears that the species of Aramides of this group do not have a brownish gray breasted juvenile plumage as does *A. axillaris* and its allies.

NOTES AND LITERATURE

BIOLOGY

The Reception of the Mutation Theory.— When the first Lieferung of "Die Mutationstheorie" appeared in 1901 a frequent question was whether the work would be made available for a larger audience by the preparation of an English translation. That the interest of Americans in this subject is very real was soon evidenced by an invitation extended to Professor de Vries to deliver a series of lectures at the University of California. A second edition of the thick volume containing these published lectures was necessary in a few months. Besides a French translation of the American lectures we now welcome an attractive German edition by Klebahn.[1]

Species and Varieties was reviewed in the pages of this journal (Am. Nat. **39**: 747–751, 1905) and it seems unnecessary to discuss the scope or contents of the work. The translator had the benefit of the corrections prepared by Professor de Vries so that the translation is comparable with the second American edition. An especially commendable feature of the present volume is a fine series of over fifty illustrations. These are drawn in part from the larger work of the author, in part from his unpublished drawings or photographs, and in part from living material or other sources.

It must be gratifying to all serious students of evolution to see the widespread interest in these works. Whether or not they admit the general applicability of de Vries's theory, they must at least realize that after long years of marking time students of evolution have at last begun to march. No one should scorn the results of comparative studies, but their limitations should always be kept clearly in mind. The spirit of experimental work is in the air and let us hope that there will be no turning back because of difficulties encountered in the way. Just here a word of warning may not be out of place. In experimental physiology and morphology it is considered essential that the factors involved and the results secured be quantitatively expressed. In ecology and evolution the impor-

[1] deVries, H. Arten und Varietäten und ihre Entstehung durch Mutation. Ins Deutche übertragen von H. Klebahn. Berlin. Gebrüder Borntraeger, 1906. Q. xii + 530 pp.

tance of quantitative methods is just as great. While de Vries was making the now celebrated experiments upon which his theory is based Pearson and his associates were developing the methods of quantitative investigation in variation and heredity. It will be unfortunate indeed if present day workers neglect this new and powerful instrument of research. But with a proper combination of experimental and biometric methods it should be possible to gain a very precise knowledge of the processes involved in species formation.

J. A. HARRIS.

A Monument to Theodor Schwann.— Theodor Schwann was born at Neuss on the Rhine, December 7, 1810. On the centennial of that date it is proposed to unveil a monument to his memory in his native town. A considerable sum is already in hand and a committee representing all countries has issued an appeal for subscriptions for the memorial. As is well known, he with Schleiden, placed the cell-theory on a substantial basis sixty-five years ago; while his later work was almost equally valuable though not so startling in character. He became an authority on fermentation, decomposition, digestion and spontaneous generation, and, not least, was the discoverer of pepsin. A monument to his associate has been erected in Jena while his master Johannus Müller has a bronze memorial in his native town, Coblenz. Contributions may be sent direct to the 'Städtische Sparkasse, Neuss am Rhein, Germany' marked 'Schwanndenkmal' or probably to the American members of the Committee, Prof. C. S. Minot of Boston and Prof. R. Ramsay Wright of Toronto.

Fitch's Basis of Mind and Morals.[1] — This book is a brief exposition of the principles of evolution as stated by Darwin and Spencer, together with a discussion of the evolution of mind and of the natural code of ethics. The point of view of the book is phenomenalistic; the style is simple, clear and direct. For those who have thought seriously about the problems of evolution the work has little value; for those who wish to be stimulated to such thought it may prove profitable.

The author contends that there should be a natural code of ethics. He does not attempt to construct such a code, but, instead states that it should be the result of man's knowledge of natural causes and

[1] Fitch, M. H. The Physical Basis of Mind and Morals. Chicago, Charles H. Kerr and Company. 1906. 266 pp.

effects. "But I repeat, he says that until men come to comprehend a natural cause for every natural effect they should be controlled in their attitude toward environment, including their brother men, by some code that will have the proper effect, however based that code may be." (p. 255.)

GEOLOGY.

The reconstruction of the Continents of Tertiary times is the topic discussed in a paper by W. D. Matthew.[1] Using the evidence furnished by the distribution of fossil and recent Mammals, he tries to reconstruct the outlines of the old land-masses, and illustrates his results by seven maps, which represent the geographical conditions of the earth's surface in Postcretaceous time (immediately after the close of the Cretaceous), in the middle Eocene, in the middle Oligocene, in the Miocene, in the Pliocene, in the early Pleistocene, and in recent times.

This paper undoubtedly marks an important progress in this branch of research. Comparing it with the last attempt to reconstruct the old continents, made by Ortmann in 1902 (Pr. Amer. Philos. Soc. **41**), we see that here only two maps were given, for the lower and for the upper Tertiary period. Neither agrees entirely with any one of Matthew's maps, although the one for the lower Tertiary corresponds rather closely to the middle Eocene map, and the one for the upper Tertiary to that of the Miocene. But complete agreement cannot be expected, considering the extreme difficulties with which such investigations are connected. Indeed, it is rather surprising that Matthew's studies, in many points, have led to results, which largely indorse the views held by Ortmann, and furnish additional support for many of the accepted features of ancient geography.

Studies of this kind are often regarded as rather phantastic and without sufficient support to render the conclusions trustworthy enough to give them universal recognition. But Matthew's paper again demonstrates that it *is* possible to express definite views as to the shape, the connections and disconnections of the continents,

[1] Matthew, W. D. Hypothetical Outlines of the Continents in Tertiary times. (Bull. Amer. Mus. Nat. Hist., **22**, 1906, p. 353–383. 7 maps).

chiefly in Tertiary times, and the agreement of the zoogeographical facts with paleontology and geology tends to show, that these reconstructions of the old continents are not merely wild speculations. However, the results cannot yet be accepted as final, and although some of the major features of old geography must be regarded as well established, much remains to be done in detail. Chief of all, additional groups of animals should be studied, and an attempt should be made to correlate the results obtained by them with those of Ortmann and Matthew; and further, attention should also be paid to the Mesozoic, and if possible, Paleozoic times. It is to be hoped that, for instance, the distribution of certain molluscs and lower vertebrates may furnish evidence with regard to these ages, although it is only natural that this task will be much more difficult, since the facts are very scanty, and their meaning is largely obscured by the changes in subsequent times.

A. E. O.

The Mountains of Cape Colony.— In the Cape Colony, southern Africa, are ranges of folded mountains very similar to the Alleghenies of the eastern United States. During the summer of 1905 Professor Davis had an opportunity to study the Cape Colony ranges while a guest of the British Association for the Advancement of Science during its South African meeting, and in this paper[1] has given a most interesting account of the ranges, comparing them with the Allegheny type. The paper will be of more than usual interest to American geologists and geographers, because of the striking similarity, in practically all essential features, of the two widely separated mountain groups, whether compared as to structure, the relation of folded areas to undisturbed plateaus, the erosion history and development of drainage adjustments, or the control exerted by the physiographic features upon transportation, etc. In climate, however, a marked contrast between the two localities exists. The paper is illustrated by a number of drawings and photographs.

D. W. J.

Natural Mounds.[2]— During the last two years a number of papers have been published describing and attempting to explain the origin of the natural mounds occurring in different parts of the country.

[1] The Mountains of Southernmost Africa. By W. M. Davis. Bulletin American Geographical Society, Vol. **38**, 593–623, 1906.

[2] Natural Mounds. By Marius R. Campbell. Journal of Geology, Vol. **14**, 708–717, 1906.

Mr. Campbell figures and briefly describes the mounds, reviews the various theories of origin, some ten in number, which have been advanced by various writers, and concludes from his own studies of the subject that the mounds have been built up by ants or small rodents, more probably by ants. A bibliography of the subject is appended to the paper.

D. W. J.

Ancient Glacial Periods.— During recent years the evidences of repeated glacial periods during ancient geological time have been accumulating so rapidly that whereas much doubt was cast upon the earlier reports of such glaciation, it is no longer possible for the unprejudiced student to doubt the conclusions which the evidence forces upon us. The famous Dwyka glacial formation of South Africa is now well known, and its equivalent in India, the Talchir. I. C. White and David White have recently reached the conclusion, independently, that the equivalent of these Permian or Permo-Carboniferous glacial deposits occurs in southern Brazil in what is called the Orleans conglomerate. Glacial deposits in Australia are reported from both the Permian and the Cambrian or older beds. A. P. Coleman has recently reported evidence of a lower Huronian ice age in Canada. Mr. Schwarz[1] discusses three glacial periods in South Africa, those in addition to the Permian Dwyka being most probably, according to the author, of Devonian and Archaean age. The relation of the glacial beds to other members of the general stratigraphic series is pointed out, and the evidence of the glacial origin considered. It is this last point which in every case is critical. The fact that a large number of reports of ancient glaciation are being published does not strengthen the evidence in favor of ancient glaciation in any particular case. Each reported instance must be critically examined as to the value of the evidence supporting it.

D. W. J.

[1] The Three Paleozoic Ice-Ages of South Africa. By Ernest H. L. Schwarz. Journal of Geology, Vol. **14**, 683–691, 1906.

PHYSIOLOGY

Hough and Sedgwick's Physiology.[1]— "The authors of this work believe that extensive and fundamental changes must be made in the elementary teaching of physiology, hygiene, and sanitation, if these subjects are ever to occupy in the curriculum of education the place which their intrinsic importance requires." This sentence from the Preface to this new book by two well-known professors of biology is the key-note to its importance, for their intention in this respect certainly has been fulfilled. Not only the students of high schools, academies, and colleges actually need to know the facts and principles set forth here, but so also does the long-graduated 'average man' if he would live well. Especially is it one more step towards the recognition educational theory is certainly about to make, that in education every part of a boy's body one is educating at the same time and in the most real manner also the capability of his whole mind.

The book is divided into two nearly equal parts: 'Physiology,' and 'The Hygiene of the Human Mechanism and the Sanitation of its Surroundings,' respectively. The latter half is subdivided into accounts of personal hygiene, domestic hygiene, and public hygiene and sanitation, with an important introductory chapter in addition.

The matter of the first part of the book is better than its arrangement in chapters, for the nervous system is placed last and the muscular mechanism early in the list. For the learner the much more preferable order is just the reverse, it being certainly difficult really to understand any one of the great organic functions until the coördinating purpose of the nervous system is mastered. One deplores too the omission of at least a brief discussion of protoplasm in general as an introduction to its differentiated natures.

A far more serious omission (but one more easily defensible) is that of the basal principles of reproduction. When all is said, at whatever length, one can but deplore the fashionable prudery of our times which keeps from youth the true and useful knowledge of their own real nature in this respect. With a decreasing birth-rate and an ever increasing 'social evil,' the information both sexes most crave is, above all others, most hard for them to obtain. The book is surely

[1] The Human Mechanism: its Physiology and Hygiene and the Sanitation of its Surroundings," Theodore Hough and William T. Sedgwick. Boston, Ginn & Company, [1907]. Pp. ix + 564. Illustrated.

not intended for grammar schools nor for the first years of the high school even, but for schools whose students might soon aspire to be husbands and wives.

The chapter on muscular activity is uniquely fine in its discussion of the necessity for physical exercise, and in combination with previous chapters on muscle-function and neural coördination almost meets the insistent demand pedagogy is beginning to make for bodily skill as a basis for learning. One misses, perhaps, an adequate description of the kinesthetic mechanism for muscular control, as well as sufficient information as to habit and the emotional reactions. On the other hand, 'rhythmic segmentation' is allowed far more prominence than the doubts as to its existence warrant.

The hygienic portion of the book is rich in clear and precise information of really great importance to everyone. Moreover it is set forth in a manner as scientific and up-to-date as could be desired. Could an enlarged wall-copy of figure 116 ("A domestic well badly situated in a farmyard"), be distributed broadcast by the state boards of health, our city hospitals would soon cease to be over-filled with typhoid patients in October and our farm-houses would be less saddened by cholera infantum in the summer.

The account of personal hygiene is at once eminently practical and entirely scientific — a needful combination seldom attained. Moreover it is more complete than is common in text-books of this sort. It seems as if too little emphasis perhaps, were placed on the importance of moisture in the air of dwellings, this need being met by continually open windows. It is the throat-specialists who best realize the general lack of moisture in the atmosphere of our houses, but there are of course other reasons (such as that moist warm air feels warmer than does dry warm air) which are important in the theory of ventilation.

Few but physiologists familiar with the required falsities as to alcohol and tobacco which reek in certain states, especially westward, will realize how excellent is the discussion of these very important topics in this book. The facts are clearly stated and the principles laid down,— their dangers in overuse any student in a school for normal persons may certainly see and be warned by for himself.

The 147 often familiar illustrations of the work are adequate and for the most part well executed.

Altogether this is an important text-book, not only in itself as a source of vital information for a host of young men and women, but as a prophecy of the present excellent trend of general education.

George V. N. Dearborn.

ZOÖLOGY

Guyer's Animal Micrology,[1] though burdened with a horrible name, is one of the best and most practical works upon microscopic technique with which we are acquainted, ranking, in this respect with Böhm and Oppel's well-known "Taschenbuch" which, by the way, is not referred to in the list of works cited on p. vi.

The especial merit of the work lies in its great practicability. It does not burden the beginner with a large number of alternatives; but starts him at once with a few reagents of almost universal availability and sets him at work with his specimens. Only when these have been carried through and converted into slides are other methods and other objects considered.

In the Appendix are given an account of the microscope and its accessories, a list of further tried and proved reagents and a table of tissues and organs with methods of preparation which will doubtless prove of value to instructors as well as to students. The list which is given embraces over 250 objects and is more than ample to illustrate any practicable course in normal histology. The final chapter of the Appendix deals with methods preparatory to microscopic preparation and study of a series of animals which are frequently used in the Zoölogical Laboratory.

Omissions of what we would like to see in such a work are few. We have found no mention of Cox's Golgi method which presents certain advantages over the silver impregnation; the Golgi method for distinguishing bile capillaries is not referred to, nor is the value of Lyons blue for differentiating cartilage. The method of rolling wax plates for reconstruction, credited to Huber (p. 128), has been in use for many years. In the 'Memoranda' on p. 30 it is stated that material which is to be kept indefinitely should be put in tightly stoppered bottles, but there is no hint as to the injurious effects of the extracts of cork and that some other method of closure should be adopted. But why find any more fault with such a useful and excellent work?

J. S. K.

[1] Animal Micrology. Practical Exercises in Microscopical Methods by Michæl F. Guyer, Chicago, University of Chicago Press, 1906, pp. ix + 240. $1.75 net.

Mollusca of Illinois and Michigan.— F. C. Baker has recently catalogued[1] the Mollusca of Illinois, enumerating in all 332 species of which 91 are terrestrial and 240 are aquatic (the figures are the author's, the discrepancy is not explained). The Unionidae number 89. The list gives localities with considerable detail; no new species are described. Bryant Walker's catalogue of the terrestrial Pulmonata of Michigan[2] is more elaborate, giving descriptions and in most cases figures, with an outline of the synonymy of the 79 species recorded from the state. In the Introduction, besides general notes on distribution, adequate directions are given for the collection and preparation of specimens.

A monograph on Anurida.— Those in charge of the Liverpool Biological Society have, for several years past, been issuing a series of short Memoirs on the morphology, life history, and œcology of various typical animals and plants found in that region. The thirteenth of the series appears in volume 20 of the Proceedings and Transactions of the society. It deals with the interesting Collembolan, Anurida and is by A. D. Imms. The habits and structure are described from original observations; the account of the development is summarized from American writers. A bibliography of 102 articles is given and the whole is illustrated by four figures in the text and by seven plates.

Reichensperger describes (Bull. Mus. Comp. Zoöl., 43, Dec. 1906) a new species of Myzostoma (*M. vincentinum*) found parasitic on *Pentacrinus decorus* from St. Vincent.

BOTANY

A popular book on Canadian wild flowers.— In 1885 the venerable Mrs. Catherine Parr Traill was among the leaders in popularizing a knowledge of American wild flowers by presenting them untechnically and attractively to those who could or would not make their acquaintance through keys and manuals. Her pioneer course has been

[1] Bulletin Ill. State Lat. Nat. Hist. 7, 1907.

[2] Published by the State Board of Geological Survey, as a part of the Report for 1905, Lansing 1906.

successfully followed in this country by many and excellent works of the same character. A new and revised edition of her book has now made its appearance.[1] Like the original, it has passed through the hands of Macoun and Fletcher, for the determination of the plants included; it should stimulate in many people of the present day that love for plants and their ways which comes through knowing what they are, and toward which the first edition did such good service two decades ago.

W. T.

Notes.— An interesting and appreciative sketch of de Vries, by a former assistant, Henri Hus, has been separately issued from *The Open Court.*

A handsomely printed volume of botanical studies presented to Kjellman on his 60th birthday has been distributed by the University library of Upsala.

A detailed account of the history of natural science in the Aberdeen Universities has been reprinted by Professor Trail from "Aberdeen University Studies."

Semon's terminology, "equally applicable to the movements of a plant or the thoughts of a man," is used by Francis Darwin in a lecture on associated stimuli, printed in *The New Phytologist* of November 30.

A lecture on "Mendelism and Microscopy" is published by Scourfield in the *Journal of the Quekett Microscopical Club* of November.

The viability of old seeds has been tested recently by Becquerel, as reported in the *Comptes Rendus* of June 25 last, and abstracted in the *Gardeners' Chronicle* of November 24.

A concrete presentation of the results of local ecological study of the modern sort is afforded by Woodhead's Huddersfield paper occupying no. 261 of the *Journal of the Linnean Society, Botany.*

Strasburger contributes an illustrated paper on the thickening of palm and screwpine trunks, to vol. 43, Heft 4 of the *Jahrbücher für wissenschaftliche Botanik.*

[1] Traill, Mrs. C. P. Studies of Plant Life in Canada. Toronto, William Briggs, 1906. 8vo. xvii + 227 pp., with 8 reproductions in natural colors and 12 half-tone engravings, from drawings by Mrs. Agnes D. Chamberlin.

Habit illustrations of a number of the economic plants of West Africa occupy Heft 5, Vierte Reihe of Karsten and Schenck's "Vegetationsbilder."

South American botany continues to receive important attention in the *Arkiv för Botanik* of Stockholm.

A morphological and anatomical study of *Ceanothus americanus* and *C. ovatus* is published by Holm in *The American Journal of Science* for December.

An extensive segregation of the components of *Rhus glabra* is effected by Greene in the *Proceedings of the Washington Academy of Sciences* of December 18th.

Agnes Chase publishes on Paniceæ in the *Proceedings of the Biological Society of Washington* of December 8.

An interesting study of the Euglenoid genus Dunaliella is published by Teodoresco in the *Revue Générale de Botanique* of September 15.

Pithyum de Baryanum is said by Raffill, in *The Gardeners' Chronicle* of November 10, to have proved a serious enemy of the Victoria, at Kew.

An illustrated monograph of Ravenelia is published by Dietel in vol. 20, Abt. 2, Heft 3 of the *Beihefte* zum Botanischen Centralblatt.

A practical account of the fungous diseases of tulips and their treatment is contributed by Klebahn to *Gartenflora* of November 1.

A small text book of fungi, including morphology, physiology, pathology, classification, etc., by Massee has been issued from the Duckworth Press of London.

A biographic sketch of Mitten, with portrait, is published in *The Journal of Botany* for October.

A new "Manual of the New Zealand Flora," conformed to the Colonial flora plan of the elder Hooker, and prepared by Mr. T. F. Cheeseman, has recently been published by the Government of New Zealand. The species that are admitted number 156 vascular cryptogams and 1415 phænogams, representing 382 genera and pertaining to 97 orders. Of the total, 1143 are peculiar to New Zealand; 366 also occur in Australia; and 108 in South America. Naturalized species have been excluded from the work; but over 600 such species are said to occur in the colony.

An excellent, conservatively handled, local flora, of a very rich region, is that of the State of Washington, by Professor Piper, recently published as vol. 11 of *Contributions from the U. S. National Herbarium*, an illustrated volume of 637 pages.

In contrast with the highly diversified flora of Washington, is the homogeneous flora of the Altamaha grit region of the coastal plain of Georgia, to which is devoted a volume of 357 pages, by R. M. Harper, forming vol. 17, part 1 of the *Annals of the New York Academy of Sciences*. In this region, comprising about 11000 square miles, only 814 species or varieties of vascular plants are recognized, and 75 of these are weeds. Mr. Harper's study has been carried out on the lines of ecological analysis with special reference to geographic distribution, and his paper is illustrated by a map and 28 half-tone plates which form one of the best series of such illustrations yet published.

Habit illustrations of antarctic vegetation are given by Skottsberg in Reihe 4, Heft 3–4 of Karsten and Schenck's Vegetationsbilder.

Further "Contributions to Canadian Botany" are being published by Macoun in current numbers of *The Ottawa Naturalist*.

The official precedings of the International Botanical Congress held at Vienna in 1905 have recently been issued from the Fischer press of Jena, in the form of a quarto brochure of vi + 262 pages: the scientific papers presented before the Congress form a similar quarto of vi+446 pages, freely illustrated, and published by the same house.

A polyglot code of the rules of botanical nomenclature adopted by the 1905 International Botanical Congress of Vienna, has been separately issued from the Fischer press of Jena. The pamphlet is indispensable for every phanerogamic herbarium. One of the most debated acts of the Congress was the adoption of a list of several hundred generic names which were considered so thoroughly established as to be exempted from supersession by earlier names which have failed to come into general use. This list is included in the pamphlet.

Raunkiaer discusses the biological types to be recognized in botanical geography, in a paper separately issued from the *Oversigt over det Kgl. Danske Videnskabernes Selskabs Förhandlinger* for 1905.

Professor Bray's "Vegetation of the Sotol Country in Texas," elsewhere published, is also printed in vol. 7 of the *Transactions of the Texas Academy of Sciences*.

For Juliana and Orthopterygium, Mr. Hemsley proposes a new Order, Julianaceæ, to go between Juglandaceæ and Cupuliferæ,—in *The Journal of Botany* for November.

Brand describes and figures under the name *Trifolium pratense foliosum*, a glabrous clover recently introduced into American cultivation from Orel, Russia. (*Bulletin no. 95*, Bureau of Plant Industry, U. S. Department of Agriculture).

A considerable number of new species of the orchid genus Acovidium are described by Ames in the *Proceedings of the Biological Society of Washington* of September 25.

The Department of Agriculture in India has begun the publication of an important series of botanical memoirs, from the Agricultural Research Institute at Pusa. The three numbers thus far received refer to "Fungus Diseases of Sugar Cane in Bengal," "The Haustorium of *Santalum album*," and "Indian Wheat Rusts." A fourth paper, on "*Gossypium obtusifolium*," and a fifth, "An Account of the Genus Pythium and some Chytridiaceæ," are also announced.

An account of Cratægus, as richly represented in the vicinty of Albany, has been separately issued by Sargent and Peck from *Bulletin 105* of the New York State Museum.

A colored plate of *Ribes cruentum* is given in *Curtis's Botanical Magazine* for November.

The first issue of *The Bulletin of the Pictou Academy Scientific Association* contains an account of the Myxomycetes of Pictou County, Nova Scotia, by C. L. Moore.

Huber publishes a synopsis of 18 recognized species of Hevea in vol. 4, no. 4, of the *Boletim do Museu Goeldi*, of Para.

The fondness of cats for *Actinidia polygama* is re-recorded by Fairchild in *Science* of October 19.

Several new Cuban grasses are described by Hackel in the first *Informe Anual de la Estación Central Agronómica de Cuba*, issued in June.

Among other papers on island botany, Supplement 4 of the current volume of *The Philippine Journal of Science* contains a list of known Philippine fungi, by Ricker.

Adams, in *The Irish Naturalist* for November, notes that a mold of fermenting hay thrives at an induced temperature as high as 135.5° F.

Magnus has separately issued from vol. 21 of the *Naturwissenschaftliche Rundschau* an account of the destructive mushroom parasite, *Mycogone perniciosa.*

An exhaustive account of a Sclerotinia-rot of apples is given by Molz in the *Centralblatt für Bakteriologie*, etc., Abteilung 2, of October 27.

A study of the influence of selected yeasts upon fermentation, with reference to cider making, by Moncure, Davidson and Ellett, forms *Bulletin 160* of the Virginia Agricultural Experiment Station.

The Ustilaginales of North America are revised by Clinton in the recently issued vol. 7, part 1, of "North American Flora," under the editorship of Professors Underwood and Britton.

A descriptive account of the economic plants of the world and of their commercial uses, by Freeman and Chandler, is being issued in fortnightly parts by Pitman and Sons, of London, under the title "The World's Commercial Products."

Brief descriptions, with 3-color illustrations, of the most noxious weeds or "proclaimed plants" of Victoria are being published by Ewart and Tovey in *The Journal of the Department of Agriculture of Victoria.*

An illustrated account of the seed of red clover, and its impurities, by Brown and Hillman, forms *Farmers' Bulletin no. 260*, of the U. S. Department of Agriculture.

Laubert gives an account of *Ambrosia artemisiæfolia* as a German weed in vol. 35, no. 5, of *Landwirtschaftliche Jahrbücher.*

Stockberger gives an economic account of *Spigelia marilandica* and its surrogates in *Bulletin 100, part 5*, of the Bureau of Plant Industry, U. S. Department of Agriculture.

A portrait of Lord Avebury forms the frontispiece to *Nature Notes* for October.

An account of the varieties of dates grown in the Figuig region is being published by Paris in current numbers of the *Revue Horticole de l'Algérie.*

"Date varieties and date culture in Tunis" is the title of *Bulletin no. 92* of the Bureau of Plant Industry, U. S. Department of Agriculture, by Kearney.

An illustrated practical guide to judging and selecting corn is given by Shoesmith in *Bulletin no. 139* of the Kansas Agricultural Experiment Station.

An economic account of the cultivation of *Agave cantula* in the Philippines is given by Edwards in *Farmers' Bulletin no. 13* of the Insular Bureau of Agriculture.

Gomolla gives an interesting account of vanilla cultivation and preparation in Africa, in *Der Tropenpflanzer* for October.

Chemical studies of Althusa, Grindelia and Pittosporum, by Power and Tutin, have recently been distributed as papers from the Wellcome Research Laboratories of London.

An interesting account of the use of tree bark etc. for bread making is given by Dillingham in the recently issued vol. 3, part 5, of the *Bulletin of the Bussey Institution* of Harvard University.

Some good root-habit photographs of Ficus are reproduced in *Arboriculture*, for October.

Biffen analyzes Mendel's laws of inheritance with reference to wheat breeding, and the inheritance of sterility in barley, in the recently issued Cambridge volume of reprints from vol. 1 of the *Journal of Agricultural Science.*

A second edition of De Vries' "Species and Varieties: their Origin by Mutation," corrected and revised under the editorship of Dr. MacDougal, has been issued by The Open Court Publishing Company. The frontispiece is an excellent but somewhat informal portrait of the author, at work.

Further evidence of the germicidal effects of copper is given, in official orthography, by Kellerman and Beckwith in *Bulletin no. 100, part 7*, of the Bureau of Plant Industry, U. S. Department of Agriculture.

Livingston publishes an important study of the relation of desert plants to soil moisture and to evaporation as *Publication no. 50* of The Carnegie Institution of Washington.

A paper on the effect of tension upon the development of mechanical tissues in plants, by Ball, is contained in vol. 7 of the *Transactions of the Texas Academy of Science.*

From a study of the strength of the bands which Thyridopteryx fastens about twigs, the results of which are published in vol. 17 of the

Report of the Missouri Botanical Garden, von Schrenk concludes that the radial force of twig growth may equal a pressure of 40 or more atmospheres.

A biographic sketch of C. B. Clarke, with portrait, appears in the November *Journal of Botany*.

A short account of the McKinley or Dinkey grove of big-trees is given by Guthrie in *Forestry and Irrigation* for October.

The Journals.— *Botanical Gazette*, November:— Chamberlain, "The Ovule and Female Gametophyte of Dioon"; Brooks, "Temperature and Toxic Action"; Cook, "The Embryogeny of some Cuban Nymphæaceæ."

The Fern Bulletin, October:— Fellows, "The Fern Flora of Maine' ; Gilbert, "*Polypodium vulgare* var. *alato-multifidum*, var. nov."; Clute, "The Genus Oleandra"; Negley, "Where Florida Ferns Grow"; Palmer, *Asplenium ebenoides* in Chester Valley, Pa."; Ferriss, "On Cultivating our Ferns"; Clute, "Rare Forms of Ferns,—I"; Squires, "A New Station for *Selaginella douglasii*"; Puffer, "The Rusty Woodsia in Cultivation."

Torreya, December:— Harper, "Some Hitherto Undescribed Outcrops of Altamaha Grit and their Vegetation"; Berry, "Leaf Rafts and Fossil Leaves"; Sheldon, "A Rare Uromyces."

Rhodora, November:— Hitchcock, "Notes on Grasses"; Blanchard, "Some Maine Rubi. The Blackberries of the Kennebunks and Wells —III"; Fernald, "Twelve Additions to the Flora of Rhode Island"; Leavitt, "Regeneration in the Leaf of *Aristolochia sipho*"; Fernald, "*Potamogeton spathæformis* a probable Hybrid in Mystic Pond."

Torreya, November:—Howe, "Some Photographs of the Silk Cotton Tree (*Ceiba pentandra*), with Remarks on the Early Records of its Occurrence in America"; Hill, "A Mississippi Aletris and Some Associated Plants"; Shafer, "*Hibiscus oculiroseus*"; Murrill, "How Bresadola Became a Mycologist"; Burnham, "A New Species of Monotropsis"; Blanchard, "A New Dwarf Blackberry."

Journal of Mycology, November:— Long, "Notes on New or Rare Species of Ravenelia"; Atkinson, "A New Entoloma from Central Ohio"; Kellerman, "Fungi Selecti Guatemalenses Exsiccati, Decade 1" [label data]; Morgan, "North American Species of Lepiota" (continued); Kellerman, "Index to North American Mycology" (continued).

The Ohio Naturalist, November:—Schaffner, Mabel, "The Embryology of the Shepherd's Purse"; Hambleton, "Key to the Families of Ohio Lichens"; McCleery, "Pubescence and other External Peculiarities of Ohio Plants."

The Plant World, October:— Arthur, "The Paired Seeds of Cocklebur"; Tullsen, "The Probable Origin of Key-Fruits"; Parsons, "Children's Gardens and Their Value to Teachers of Botany and Nature Study"; Blumer, "Wild Fruits and Shrubs of the Priest River Valley"; Taylor, "The Germination of the Morning Glory."

The Bryologist, November:— Fink, "Further Notes on Cladonias —VIII"; Hagen, "A Study of *Tetraplodon australis*"; Bailey, "Vancouver Island Bryology—I"; Lorenz, "Notes on the Mosses of Waterville, N. H."; Haynes, "Ten Lophozias"; Collins, "Notes on *Polytrichum commune*."

Bulletin of the Torrey Botanical Club, October:— Arthur, "New Species of Uredineæ—V"; Harper, "Notes on the Distribution of some Alabama Plants"; Piper, "Notes on Calochortus."

Journal of the New York Botanical Garden, November:— Britton, "Recent Explorations in Jamaica"; Underwood, "Report on the Condition of the Tropical Laboratory"; Taylor, "Collecting in the Mountains West of Santiago, Cuba."

Journal of Mycology, September:—Kellerman, "A New Plowrightia from Guatemala"; Arthur, "A New Classification of the Uredineæ"; Bain and Essary, "A New Anthracnose of Alfalfa and Red Clover"; Atkinson, "Two New Species belonging to Naucoria and Stropharia"; Morgan, "North American Species of Lepiota (continued)"; Hedgcock, "Some Wood-Staining Fungi from Various Localities in the United States"; Kellerman, "Notes from Mycological Literature—XXI," and "Index to North American Mycology (continued)."

Of Mr. Elmer's *Leaflets on Philippine Botany* the following articles have been issued:— Elmer, "Philippine Rubiaceæ," "A Fascicle of Benguet Figs," "Additional New Species of Rubiaceæ," and "Pandans of East Leyte"; and Copeland, "A New Polypodium and Two Varieties."

(No. 482 was issued February 16, 1907).

Young man, aged 26, excellent collector and setter of Lepidoptera, can also make bird skins, desires a place as assistant with museum, professional naturalist or private collector. Is prepared to travel abroad. Write C., Box 4373 Willings, 125 Strand, London, W. C. England.

ARE YOU INTERESTED IN PHOTOGRAPHS OF BIRD-LIFE?

Then you should send One Dollar for a year's subscription to

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

Edited by J. GRINNELL.

"The photographic illustrations alone are worth the price of subscription."
—*The Critic.*

Contributors in the past have included—
Robert Ridgway, Dr. A. K. Fisher, Vernon Bailey, Maj. Mearns, Florence Merriam Bailey, Joseph Grinnell, W. K. Fisher, Louis A. Fuertes, E. W. Nelson, F. S. Daggett, Joseph Mailliard, and other well known ornithologists.

SUBSCRIPTION, $1.00. SAMPLE COPY, 20 CENTS.

H. T. CLIFTON, BUS. MGR., P. O. BOX 404, PASADENA, CALIF.

School Science and Mathematics

A MONTHLY JOURNAL FOR SCIENCE AND MATHEMATICS TEACHERS

It is the only magazine of its kind published in the English language. It gives new ideas and methods of scientific and mathematical instructions—and acts as a clearing house for all that is advanced and good in scientific and mathematics instruction. It is the official organ of many science and mathematics teachers' associations.

EIGHT DEPARTMENTS—Botany, Chemistry, Earth Science, Mathematics, Metrology, Problems, Physics and Zoology.

"Almost a necessiry." Bruce Fink, Professor of Botany, Iowa College.
"The practical hints are valuable to teachers." H. C. Cooper, Ass't Professor of Chemistry, Syracuse University.
"I value the magazine highly. It is most excellently conducted." John S. Collins, Ass't Supt. of Schools, St. Louis, Mo.
"The Problem Department is very interesting and adds greatly to the value of the magazine." H. E. Cobb, Professor of Mathematics, Lewis Institute, Chicago.
"I do not intend to dispense with the magazine as long as it continues as helpful as it has proven to be in the past." Etta M. Bardwell, Biology Department, High School, Ottumwa, Ia.
"I feel that 'School Science' should be in every high school. I shall be glad to further the interests of the journal whenever it is possible." W. M. Cobleigh, Department of Physics, Montana State college of Agriculture.
"I wish to express my appreciation of your magazine. It is a most helpful and inspiring pastime to read the sensible, to-the-point articles it contains." W. T. Heilman, Instructor in Mathematics, Central High School, Columbus, O.
"Your paper is not in the usual class of school papers. I wish to help along the kind of work you are doing." Geo. P. Bristol, Director Summer Session, Cornell University.

$2.00 PER YEAR. 25 CENTS PER COPY.

SCHOOL SCIENCE AND MATHEMATICS

440 KENWOOD TERRACE, CHICAGO, ILL.

SCHOOL SCIENCE AND MATHEMATICS will be sent for THREE MONTHS for 50 cents to a new subscriber mentioning The American Naturalist.

Bird-Lore for Christmas

Tell us to whom you wish us to send BIRD-LORE for you during 1907, and we will forward a Christmas Card giving your name as donor, a beautiful, life-size, colored drawing of the Evening Grosbeak, by Horsfall, and a free copy of the 100-page Christmas number of BIRD-LORE, containing twelve colored figures of birds. All these will go in time to be received, with your greetings, on Christmas Day, and BIRD-LORE will follow, as published, throughout the year.

A valuable present, easily made; whether to a friend or to yourself.

$1.00 a year; for Christmas, five subscriptions for $4.00, three subscriptions for $2.50.

Bird-Lore

HARRISBURG PENNSYLVANIA

READ

Economic Geology

THE

New Semi-quarterly Journal

devoted to discussions relating to the geological occurrences of materials of ECONOMIC VALUE, with particular reference to the genesis of ores.

BOARD OF EDITORS.

EDITOR.

JOHN DUER IRVING

Lehigh University, South Bethlehem, Pa.

ASSOCIATE EDITORS.

WALDEMAR LINDGREN, Washington.
JAMES F. KEMP, Columbia University, New York.
FREDERICK LESLIS RANSOME, Washington.
REINRICH RIES, Cornell University, Ithaca.
MARIUS R. CAMPBELL, Washington.
CHAS. K. LEITH, University of Wisconsin, Madison, Wis.
F. D. ADAMS, McGill University, Montreal, Quebec.

TERMS.

$3.00 per year to subscribers in the United States, Canada, Mexico, etc.
$3.75 per year to subscribers in other countries.

ECONOMIC GEOLOGY PUBLISHING COMPANY,
W. S. Bayley, *Business Manager*,
South Bethlehem, Pa.

Dear Sir:

Please send the Economic Geology to the address below for a year from.....190 . Enclosed you will find $\begin{matrix}\$3.00\\\$3.75\end{matrix}$ in payment of same.

NAME.....

ADDRESS .....

DATE..... STATE.....

N. B. Post Office orders should be made payable to W. S. BAYLEY, Manager, South Bethlehem, Pa.; checks should be made payable to GEORGE OTIS SMITH, Treasurer.

BERGEN'S
ELEMENTS OF BOTANY

REVISED EDITION

By JOSEPH Y. BERGEN,
Recently Instructor in Biology in the English High School, Boston

Including Key and Flora for Northern and Central States. 12mo. Cloth. 283 + 257 pages. Illustrated. List price, $1.30; mailing price, $1.45. Without Key and Flora. List price, $1.00; mailing price, $1.10.

Issued also in three special editions with a Key and Flora for each: Pacific Coast Edition, Southern States Edition, and Rocky Mountain Edition. List price, $1.30 each; mailing price, $1.45.

BERGEN'S "Elements of Botany," Revised Edition, is designed to furnish a half-year course in the subject for students in secondary schools. It covers all the ground which ordinary classes can traverse in the time indicated, and presents only those topics which are essential to an elementary course in the science.

It differs from the earlier editions of the "Elements" mainly in the greater stress laid on the topics of ecology and cryptogamic botany, in the somewhat abbreviated directions for histological work on seed plants, and in the greatly improved quality of the illustrations. Minor changes will be found on almost every page.

THE BOOK IS CHARACTERIZED

By the natural method of presentation, introducing the pupil first, as Professor Huxley recommended, to the comparatively familiar forms and processes of plant life.

By the sparing use of technical terms, employing these only when they are indispensable for the sake of clearness or of brevity.

By the treatment of the structures and the functions of plants consecutively, not in widely separated portions of the book.

By the intimate combination of laboratory work with discussion, taking pains, however, not to tell the pupil, either in words or by means of illustrations, what he is to see before he sees it for himself.

By the accuracy of the illustrations in detail, the half tones being used *only to give general effects, never for minute organs or structures.*

By the fact that four special keys and floras have been prepared to accompany the text. This allows the student in any part of the country to obtain practice in the determination of species of phanerogams, and to get a practical idea of their relationships and classification by means of a simply written and inexpensive flora of his own region.

BOTANY NOTEBOOK

To accompany Bergen's Text-Books on Botany, and for general use in Botanical Laboratories or for Secondary Schools. Square 4to. Cloth. 144 pages. List price, 45 cents; mailing price, 60 cents.

BERGEN'S Notebook was prepared with the particular view of minimizing the amount of routine dictation for both teacher and pupil without doing any of the latter's thinking for him. Not only will it save time and trouble, but it will also lead the pupil to perform neat and accurate work.

GINN & COMPANY PUBLISHERS

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS
WILLIAM E. CASTLE
EDWIN G. CONKLIN
CHARLES B. DAVENPORT
HERBERT S. JENNINGS
FRANK R. LILLIE
JACQUES LOEB
ROSS G. HARRISON, *Man. Ed.*
THOMAS H. MORGAN
GEORGE H. PARKER
CHARLES O. WHITMAN
EDMUND B. WILSON

Volume I, containing 616 pages, 5 plates, and 478 text illustrations, and Volume II, containing 630 pages, 12 plates, and 228 text illustrations, are now complete.

CONTENTS OF VOLUME III

No. 1 — FEBRUARY, 1906

Studies on Chromosomes. III. The Sexual Differences of the Chromosome-Groups in Hemiptera, with Some Considerations of the Determination of Sex. . . . . **Edmund B. Wilson**

An Examination of the Effects of Mechanical Shocks and Vibrations Upon the Rate of Development of Fertilized Eggs . . . . **David D. Whitney**

Morphology of the Parthenogenetic Development of Amphitrite. **John W. Scott**

The Development of Fundulus Heteroclitus in Solutions of Lithium Chlorid, with Appendix on its Develo. ment in Fresh Water. **Charles R. Stockard**

Partial Regeneration of the Sperm-Receptacle in Crayfish. . **E. A. Andrews**

Experimental Study of Light as a Factor in the Regeneration of Hydroids. . . . . **A. J. Goldfarb**

No. 2 — JULY, 1906

Experiments on the Behavior of Tubicolous Annelids . . . **C. W. Hargitt**

Inheritance of Dichromatism in Lina and Gastroidea . **Isabel McCracken**

The Elementary Phenomena of Embryonic Development in Chætopterus. . . . . **Frank R. Lillie**

The Regeneration of Grafted Pieces in Planarians . . . **Lilian V. Morgan**

No. 3 — SEPTEMBER, 1906

Locomotion of Amoebae and Allied Forms. . . . . **Oris P. Dellinger**

The Influence of Light and Heat on the Movement of the Chromatophore Pigment, especially in Lizards. . . . . **George H. Parker**

Light Reactions in Lower Organisms. I. Stentor Coeruleus. . **S. O. Mast**

Some Reactions of Caterpillars and Moths. . . . . **Alfred G. Mayer and Caroline G. Soule**

Modifiability in Behavior. II. Factors Determining Direction and Character of Movement in the Earthworms. . . . . **H. S. Jennings**

A Study of the Spermatogenesis of Coptocycla Aurichalcea and Coptocycla Guttata, with Especial Reference to the Problem of Sex Determination. . . . . **W. N. Nowlin**

No. 4 — IN PRESS

The Influence of Gases and Temperature on the Cardiac and Respiratory Movements of the Grasshopper. . . . . **E. A. Walling**

The Physiology of Regeneration. . . . . **T. H. Morgan**

Torsion and Other Transitional Phenomena in the Regeneration of the Cheliped of the Lobster (Homarus Americanus). . . . . **Victor E. Emmel**

The Relation Between Functional Regulation and Form Regulation. **C. M. Child**

Studies on the Development of the Starfish Egg. . . . . **D. H. Tennent and M. J. Hogue**

Hydranth Formation and Polarity in Tubularia. . . . . **T. H. Morgan**

PRICE OF SUBSCRIPTION PER VOLUME — *Payable in Advance*

To subscribers in the United States, Canada, and Mexico,	$5.00
To subscribers in other Countries,	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount.

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to THE JOURNAL OF EXPERIMENTAL ZOÖLOGY. Address all communications to

THE JOURNAL OF EXPERIMENTAL ZOOLOGY,
N. E. COR. WOLFE AND MONUMENT STREETS,
BALTIMORE, MD., U. S. A.

PLEASE MENTION THIS JOURNAL.

The Great English Magazines

DO YOU know them—know what they are publishing—read them—subscribe for them? There are THE EDINBURGH REVIEW and the QUARTERLY; the CONTEMPORARY, FORTNIGHTLY, MONTHLY, INDEPENDENT, WESTMINSTER, and NINETEENTH CENTURY REVIEWS; BLACKWOOD'S, CORNHILL, MACMILLAN'S, GENTLEMAN'S, and PALL MALL MAGAZINES; the SPECTATOR, the SATURDAY REVIEW, the SPEAKER, the OUTLOOK, PUNCH and others. No matter how many American magazines you read, you need to know something of our English contemporaries. The one convenient, sensible, inexpensive way is to subscribe for **The Living Age,** which gives every week the best contributions from current numbers of the foreign periodicals. Its scope includes literature, science, history, politics—especially timely discussions of public affairs; travel and exploration: essays, reviews and criticisms; fiction—both serial and short stories. President Roosevelt, Chief Justice Fuller, and thousands of other people who want to be cosmopolitan in their reading are subscribers for **The Living Age.** Founded in 1844. $6 a year, $1 for 3 months' trial. Specimen copy free.

ADDRESS

THE LIVING AGE CO.

6 Beacon Street, . Boston, Mass.

VOL. XLI, NO. 484 APRIL, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

Page

I. The Geographic Distribution of Closely Related Species
DR. ROBERT GREENLEAF LEAVITT 207

II. The Coincident Distribution of Related Species of Pelagic Organisms as Illustrated by the Chætognatha . . PROF. CHARLES ATWOOD KOFOID 241

III. The Attached Young of the Crayfish *Cambarus clarkii* and *Cambarus diogenes* . . . . . PROF. E. A. ANDREWS 253

IV. Notes and Literature: *Biology,* Beebe's Log of the Sun, Laloy's Parasitism and Mutualism; *Geology,* Relative Geological Importance of Continental, Littoral, and Marine Sedimentation, Observations in South Africa, Geology of the Big Horn Mountains, A Glacial Lake in Tibet; *Zoölogy,* A Statue of Lamarck, Gardiner's Maldive and Laccadive Archipelagoes, Kollmann's Atlas of Human Embryology, The Systematic Position of the Tubinares, Beebe's The Bird, The Conus Arteriosus in Teleosts, Does half of an Ascidian Egg give rise to a whole Larva? Digestive processes in Collembola, Fresh Water Amphipods of North America, Some Problematic Worms; *Botany,* Sukkulente Euphorbien 275

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca.*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Cornell University*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.Sc., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in Anthropology, General Biology, Zoology, Botany, Paleontology, Geology and Physical Geography, and Mineralogy and Petrography. The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; and in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, critical reviews of recent literature, and a quarterly record of gifts, appointments, retirements, and deaths.

All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to THE AMERICAN NATURALIST, Cambridge, Mass.

All business communications should be sent direct to the publishers.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *April, 1907* No. 484

THE GEOGRAPHIC DISTRIBUTION OF CLOSELY RELATED SPECIES.[1]

BY ROBERT GREENLEAF LEAVITT.

THE botanical researches of the members of the New England Botanical Club are largely taxonomic and floristic. With some of us this is vocation, with others avocation. The majority perhaps pursue the study of plants in the field and make collections of them in herbaria for their own personal satisfaction. Floristic studies may properly be an end in themselves, whether followed as a business or only for recreation. In the latter case they need no further justification than the fine and pure pleasure they afford to those who love them for themselves. But the results of these studies, for whatever conscious motive pursued, may have an application and a destination far beyond our private aims. Collections of specimens and reports of distribution recorded in accessible journals by well-informed non-professional as well as professional botanists, may help materially in answering some of the largest questions of biological science. In this paper I hope to make it clear that refined taxonomy and most thorough-going plant geography may have a direct relation to the enormously difficult problem of evolution.

Organic geography has, indeed, already served the cause of evolution,— in aiding to secure general acceptation of the Descent Theory. Darwin and Wallace, drawing upon the works of taxonomers, were able to point to features in the distribution of

[1] A paper read before the New England Botanical Club at the meeting of Feb. 1, 1907. Published as Contribution from the Ames Botanical Laboratory, no. 6.

species which support the notion of common descent. Plants and animals, they said, occur upon the surface of the globe just as if they had originated by evolution, and in a manner unintelligible on the assumption of special creation. Species are universally found in the neighborhood of other species which they resemble; or to put this generalization in evolutionary phrase, species arise in geographic proximity to the species from which they may be supposed to have sprung. The geographic evidence was an important part of the testimony accumulated by Darwin ('59), to which he gives two of the fifteen chapters of the "Origin of Species." Wallace ('55) had already published an essay arguing for the evolutionary conception of organic history, the main thesis being this: "Every species has come into existence coincident both in time and space with a pre-existing closely allied species." Thus the evolutionist has been under deep obligation to the taxonomer from the beginning.

The obligation is likely to be much increased with the lapse of time. I do not agree with D. H. Scott, that the determination of the actual course of descent is the ultimate, or chief, object of the scientific systematist.[1] The fact of evolution being admitted, and the course of evolution having been ascertained, there still remains the question, "By what methods have new forms emerged from old ones?" — a subject not less interesting or important than the others, from any point of view. It seems to me, furthermore, that the final goal of phytogeography is not reached in the reconstruction of the continents and islands of former epochs, and the reviving of ancient states and changes of climate, through the study of the history of the vegetation of the earth; nor is its purpose satisfied in teaching us through its ecological aspects, that plants are marvellously and multifariously adapted to their environments. Biologically considered, there is a still more valuable product yet to be yielded by these sciences. Organic geography will, I believe, unite with systematic botany and zoölogy and with experimental morphology in composing the solid basis of an adequate theory of evolution.

[1] The present Position of Palæozoic Botany, Lotsy's Progressus Rei Botanicæ, **1**: 139 (1907).

The finely discriminative work of modern taxonomers, much as it confuses and discourages students of other aspects of biologic science, is necessary for several reasons but especially is it necessary from the point of view of the evolution problem. Doubtless systematic and experimental work will be more frequently coöperative henceforth, and such studies as those of Alexis Jordan, de Bary, Rosen and Wittrock will be repeated with many of the so-called polymorphic plant groups by students of the greater problem.

This view is apparently opposed to that lately expressed by a prominent worker in experimental evolution, who seems to deny this applicability. "The underlying fault," he says, "consists in the fact that taxonomic and geographic methods are not in themselves, or conjointly, adequate for the analysis, or solution, of genetic problems. The inventor did not reach the solution of the problem of the construction of a typesetting machine by studying the structure of the printed page, but by actual experimentation with mechanisms, using printed pages only as a record of his success. Likewise no amount of consideration of fossils, herbarium specimens, dried skins, skulls, or fish in alcohol may give any actual proof as to the mechanism and action of heredity in transmitting qualities and characters from generation to generation, although from such historical data the general trend or direction of succession may be traced." — MacDougal (:06, p. 4).

Nevertheless, it may be shown that, while such studies are not in themselves adequate to the solution of genetic problems they have a very high corrective and evaluatory worth.

Geographic studies founded on an exact taxonomy have a corrective function. It is axiomatic that no theory having its origin in experiment can be accepted if it seems to be in fundamental discord with what we know of the present disposition of the organic world. For example, the theory of Mutation as developed by de Vries cannot be accepted for the animal kingdom, if, as seems to certain zoölogists, it is irreconcilable with the facts of the distribution of animals. And even if an hypothesis is not positively excluded by the facts, it may be weakened or practically nullified by comparison with large bodies of facts

gathered broadly; so that we may fairly ask the experimental school to admit that results, however well proved for the conditions established by the experimenter, ought to be assigned little worth if they find only a trivial correspondence in nature at large. We make the same demand of the physiologist with respect to such a phenomenon as geotropism, for instance. The extended study of this form of irritability has its justification only in the fact that plants in nature so widely show the effects of geotropism in their forms; the value of the experimental results is great because the phenomenon is manifestly widespread in free nature, being observable in the erect attitude of countless main axes in field and forest, in the fixed angles of side stems, the vertical descent of tap-roots, etc., etc. In like manner a true theory of specific origins should find strong confirmation in the study of the broadest aspects of plant and animal life. Every grand agent of specific modification should leave its distinctive mark upon the character of life as a whole, and if we rightly apprehend the nature of the agent we may expect to be able to distinguish its special mark or effect when we know plants and animals thoroughly. I think that it will appear from considerations which I now bring before you that the distribution of species must have peculiarities corresponding to the particular class of evolutionary forces which have been at work. If this be so, suitable studies in geographic taxonomy must possess high evaluatory worth when we wish to estimate theories of evolution.

THE EFFECTS OF DIFFERENT EVOLUTIONARY AGENCIES UPON SPECIFIC DISTRIBUTION

Let us examine the necessary effects of the chief supposed evolutionary agencies upon the character of specific distribution; and first contrast Natural Selection in Darwin's stricter sense with Mutation, in this regard. Natural Selection works within specific limits. Its materials are the small, or individual, variations within the species. By the accumulation of these variations as they occur from generation to generation new characters are built up. The change in a species is slow and the whole species within a given competitive area moves along together. When

we consider that sufficient change has occurred to warrant the epithet 'new,' as applied to the condition of the group, we find that the new species has risen upon stepping stones of its dead self, since the survival of the fittest has had its converse in the extinction of the unfit — that is, the 'old' species —; and in the given area only a single new species is found replacing the vanished old one. For any given area of competition the transforming effect of Natural Selection then, is monotypic. Romanes (:06, ch. I.) clearly states the truth that Natural Selection without isolation effects monotypic evolution, and only by the aid of isolating factors of some kind results in polytypic evolution. Nägeli's earlier exposition of the monotypic effect of Natural Selection was explicit (Nägeli, '73).

On the other hand Mutation breaks the species and momentarily at least, must give a polytypic aspect to the group within a specific area. The parent species is contemporaneous with the new species to which it gives rise. The new and the old stand side by side for a time, without geographic isolation and in general without isolation of any sort. This is the primary condition. Subsequently competition may leave only one of the several original forms in an area. In some instances topographic (ecological) separation of the mutants, or chronal isolation in respect to flowering or breeding time, a physiological isolation may be the immediate result of Mutation. But as a rule the first effect of Mutation must certainly be the allocation of closely related species, or kinds, in the same area without any sorting or separation.

If we compare Orthogenesis, acting under guidance of the environment, with Natural Selection on the one hand and Mutation on the other, we see that Orthogenesis must in many respects agree with Natural Selection rather than with Mutation as concerns the distribution of its products — species. Throughout a single region of uniform ecological character the effect of environmental moulding, so-called, upon a given organic stock must be monotypic. But if the ecological conditions are diverse in a geographic district, as they always are when the surface is varied, we may expect to find as many kinds of plants or animals derived from a single stock as there are ecologically different environ-

ments in the district; or, if interbreeding suffices to reduce the diversity in some degree, at least several kinds perferring different habitats. While in the broader geographic sense this effect would be polytypic, in that any geographic district might have several different closely allied types, each type would fit a particular set of conditions; there would be definite allotment and topographical separation of the derivative species, and each ecological field would present a monotypic aspect. A distribution quite distinct from that due to recent Mutation would be found.

Thus while the geography of species may or may not be decisive as between the evolutionary theories known by the names Natural Selection and Orthogenesis, both these modes are distinguished from Mutation in the immediate effects which they have upon distribution. Such specific distribution as Moritz Wagner asserted to be universal or almost universal, if it could be proved, would be practically fatal to the Mutation Theory regarded as a general explanation of specific evolution.[1]

It is hard to see on what ground the experimentalists can deny the competence of geographic evidence. Indeed they appear at times to recognize the propriety of the appeal to nature; De Vries refers to Draba, Viola and similar groups, and MacDougal in the paper already cited alludes to studies of plant distribution and adduces the case of closely related Opuntias in the Arizona desert. The distinguished zoölogist who recently assumed to pass upon the merits of the Mutation Theory, evidently without

[1] Yet Darwin (Orig. Sp., ch. IV.) in his theory of Divergence of Character, seems to allow polytypic evolution within an area by means of Natural Selection. He thinks geographic isolation unnecessary. Weismann (:04, 2: 338) argues against the necessity of isolation and for a polytypic condition as possibly arising by Natural Selection, alleging in support of this view sexual dimorphism, and polymorphism in species of animals. To which it may be replied that we do not know whether the diverse forms in the same species of animals have arisen by Natural Selection. In the absence of evidence, the contention becomes a theoretical one, in which Romanes ('86, pp. 343, 386), Gulick ('88, pp. 202–206) and Nägeli seem to have the clearer views, and I have accepted their opinion. Whichever side is taken, *it has to be allowed that a uniformly monotypic geographic distribution excludes Mutation.*

much knowledge of De Vries's work and apparently after a reading of only the popular lectures published in this country,[1] was at least thus far right, that he searched for indications of mutation in the distribution of animals. The evidences should be found even in museums, providing the museums are representative, and providing mutation is a sufficient explanation of the origin of species.

The Necessity of Isolation: Mendelian Inheritance

Before coming to an examination of the facts as they are represented by writers, it will be well to consider for a moment a theoretical side of the subject, namely the supposed *necessity of isolation* as a factor in the evolutionary process. Granting that new forms may appear upon the scene by Mutation, what is to become of them? How can Mutation be said to originate new species — that is, stable groups — if through interbreeding the mutants are at once swallowed up by the parent species with which they grow commingled? The opponents of the Mutation Theory hold that the isolation which the experimenter practices in his garden by means of paper bags, etc., is lacking in nature and that this difference between the garden and free nature vitiates the experiments.

The need of isolation is well, and for the present sufficiently, discussed in the writings of Romanes and Gulick; the latter has treated every form of isolation in an exhaustive fashion, chiefly from the theoretical standpoint and upon the basis of the very limited knowledge of heredity of a few years ago. The conclusion of these authors is that some kind of segregation or isolation is necessary for the success of a new race. While Wagner ('89) saw only spatial isolation as giving the needful security, Romanes (:06) and Gulick (:05) have shown, as well as can be shown deductively, that other forms of isolation may suffice, such as

[1] Is it too much to ask that those who undertake to discuss deVries's theories shall read his evidence? The lectures in English (Species and Varieties, Chicago, 1905), doubtless serve a useful purpose in popularizing, but incidentally have done some harm in leading certain critics to suppose that they may find therein an adequate exposition of principles and evidence.

difference of breeding time, difference of local habitat, and physiological properties precluding inter-breeding. The clear discussions of Romanes and Gulick have rendered superfluous much in recent disputes on Isolation and Evolution.

Lately new conceptions in the theory of heredity have materially changed the conditions of the argument. Experiment has shown that new characters may not be immediately swamped by promiscuous breeding, but may on the contrary, in the fusion of new and old races, predominate in full force over old characters which they sometimes have the power of entirely subduing.[1] While this result is very suggestive, too little is as yet positively known to make an extended discussion at all profitable. Those who are inclined to argue the matter may well take caution from Davenport's opinion on the integrity of unit characters. "While admitting, thus, the reality of unit characters, the further study of the evidence of hybridization in poultry has led me away from the conception that they are rigid and immutable as atoms are, which may be combined and recombined in various ways and always come out of the process in their pristine purity. This is by no means the case. Very frequently, if not always, the character that has been once crossed has been affected by its opposite with which it was mated and whose place it has taken in the hybrid. It may be extracted therefrom to use in a new combination, but it will be found to be altered. This we have seen to be true for almost every characteristic sufficiently studied — for the comb form, the nostril form, cerebral hernia, crest, muff, tail length, vulture hock, foot feathering, foot color, ear lobe, and both general and special plumage color. Everywhere unit characters are changed by hybridizing.

"How does this fact bear on the rival theories of evolution? It has an important bearing on them. It is not in accord with the statements of de Vries quoted above: 'The characteristics of organisms are built up of units that are sharply separable one from another,' and 'Transitions exist between the units as little as between the molecules.' Single comb is one unit and pea

[1] Besides the Mendelian results see also de Vries (: 03, **2**, p. 396 *et seq.*) on the crossing of mutants with the parent species.

comb is a different unit, but they are not sharply separable. Crest and no crest are units, but they run into each other in hybridizing. Unit characters may show transitions, and, if so, they may have originated gradually, so far as I see. It does not follow that they must have originated gradually" — Davenport (:06, p. 80).

Castle and Forbes's results with guinea pigs indicate the same modifiability of unit characters. These authors (:06, p. 13) say: "From the foregoing observations it is clear that, while the long-haired and short-haired conditions are sharply alternative to each other in heredity, the gametes formed by cross-breds are not in all cases pure. Frequently they consist of a blend or a mixture of the two alternative conditions, constituting in effect a new condition intermediate between the other two. A study of other characters alternative in heredity yields results somewhat similar.

"Albinism is, in heredity, the most sharply alternative of characters, yet cross-breeding between albino and pigmented guinea-pigs may modify the character both of the albino race and of the pigmented one. This modification may take on a variety of forms, as has elsewhere been pointed out (Castle, :05). It may result in the production of mosaics (pigmented animals spotted with white), or of albinos with a modified peripheral pigmentation, or of albinos visibly like their ancestors but transmitting a different set of latent characters. Again, the rough or rosetted coat of certain races of guinea-pigs is sharply alternative to smooth coat, yet cross-breeding of rough with smooth races may induce curious modifications of the rough character or produce smooth individuals bearing the merest trace of the rough character.

"All these facts are in harmony with the hypothesis, for which there is strong evidence on the cytological side, that each separately heritable character is represented by a different structural element in the germ (egg or spermatozoon). In fertilization the paternal and maternal representatives of a character become more or less closely united, this union persisting through all subsequent cell-generations until the new individual forms its sexual elements. At that time the paternal and maternal representatives of a character separate from each other and pass into different cells.

"But the paternal and maternal representatives of a character may in the meantime have exercised on each other a considerable influence. In the case of some characters, as ear-length in rabbits (Castle, :05a), they completely blend and intermingle, so that a new character is produced strictly intermediate between the conditions found in the respective parents.

"In other cases the modification may be slight, as if the paternal and maternal representatives of a character had been scarcely more than approximated. Sometimes in cases of alternative inheritance no influence of the cross is observable in certain of the 'extracted' individuals, but if any considerable number of individuals is examined, others will be found in which the cross-breeding manifests its influence. From this we conclude that gametic purity is not absolute, even in sharply alternative inheritance."

These are very interesting qualifications of the Mendelian principle of gametic purity. They suggest that new characters might be swamped by repeated crossing, unless they were of such overwhelming importance that they quickly won out in the struggle for existence, to the immediate extinction of the bearers of the older alternative characters. However, discussion may here well wait upon further discovery.

But this may be said: If characters are gradually modifiable, time becomes a necessary element in experiments on evolution and possibly long periods of time may be needed for the demonstration of certain slow natural processes. For the present we may well hesitate to accept the conclusion that Mutation is the sole and only possible mode of evolution. Refreshing as the new method of research is, in the midst of oceans of tiresome speculations, and most valuable and even absolutely indispensable as the results already are, the latter are certainly small compared to the bulk of our ignorance regarding morphogenetic processes. Those who are free from inexpugnable prejudice on the one hand and from infatuation with new ideas on the other, will look for some independent means of estimating the probable significance of the new theories. It is the chief object of this paper to suggest that such estimation may be rested upon the evidence of organic geography when the evidence is available in sufficient body.

If we were right in what was said above about the specific effects of different modes of evolution upon distribution, the first question to be asked of the geographer is this: Are species universally so distributed that each one occupies a region of its own, or a habitat of its own; so that even the nearest related species are strictly separated in space, either in the broad geographic sense, or at least topographically?

It is to be noted that the inquiry has two steps, or stages. The first relates to the distribution of organisms in the broader sense, and it is inquired whether closely related species are found in identical districts, or have largely coincident ranges, in many cases. The adherents of the Mutation Theory expect to find a considerable proportion of such instances. Certain of its opponents have believed that the advance of the theory might be blocked on this first level. But if their efforts fail here they are prepared to fall back upon the second line of defence. The second stage of the inquiry relates to topographical distribution, or distribution in relation to ecological conditions, and asks whether any of the allocated forms — if some are found — exist side by side without even local segregation. Disciples of de Vries expect that instances will occur in such numbers as to satisfy the demands of their theory; while the opposite party thinks that practically no instances will be discovered giving countenance to the idea of Mutation. They expect that all cases of general geographic coincidence of range will be accounted for by ecological segregation, affording practical isolation; and so hope to withstand the final assault of the Mutationists.

The application of the botanical evidence presented in this paper is to the first stage of the inquiry. Some of it is manifestly applicable to the second stage also.

Specific Distribution in the Animal Kingdom

We may briefly review some of the chief contributions to our knowledge of the distribution of animal species. Moritz Wagner, Professor of Zoölogy in Munich, perceived the close relation which distribution may have to the problem of evolution and began to publish upon this subject very shortly after the appear-

ance of Darwin's Origin of Species, first as an advocate of the theory of Natural Selection, but shortly as its opponent. Through twenty years of controversy he insisted upon the inadequacy of Natural Selection, and as the prime factor in the diversification of species sought to substitute Spatial Separation and to establish his own Law of Migration and Colony-formation. He supposed a new species to arise by the migration or escape of a single individual or of a pair from the domain of the old species into new territory, where in geographic isolation and freedom from the influence of the old stock a new race might be founded. The divergence of the race from the old type he supposed to result (Wagner, '89, pp. 286–295, 401) (1) from the individual peculiarities of the parental pair or individual, which peculiarities in the absence of the normalizing influence of interbreeding with the whole body of the old stock would necessarily become accentuated; and, (2) from the new environment. His theoretical views, which throughout are questionable, are of less consequence than the facts which he adduced in their support; the facts indeed upon which he first formed these views. Wagner himself was a traveler, observer, and collector in several parts of the world and continually recurs in his writing to his experience in the field with regard to endemic, narrowly restricted species-forms and constant local varieties occurring in overwhelming numbers. His illustrations are drawn from all classes of animals and to some extent also from plants. He represents specific distribution as having a strictly mosaic or chain-like character. Everywhere we find vicarious species and local races in separate habitats. The facts are presented at great length and with careful detail, and seem to form a consistent body of knowledge, which impresses one as being pregnant with a rational principle of wide import.

Mr. C. H. Merriam about a year ago addressed the zoölogical section of the American Association for the Advancement of Science on the topic, "Is Mutation a factor in the evolution of the higher vertebrates?"— (Merriam, :06). While many of the arguments and conclusions regarding evolutionary processes belong, to my mind, too largely in the conjectural category, and while this author's grasp upon the real character of de Vries's work and upon his theory seems comparatively feeble, the data

of distribution brought forward for several groups of mammals are valuable. Dr. Merriam considers the geographic relations of certain American rats, chipmunks, and ground squirrels; and refers besides to other groups. His representation of specific distribution agrees with that held by Wagner, with a qualification. Merriam shows that the mammals in question occupy distinct areas with very little exception, but that the areas often overlap, and that the overlaps are likely to constitute narrow transition zones characterized by the presence of intergrades. Actual physical barriers are often wanting.

President David Starr Jordan has also discussed the Mutation question from the standpoint of organic geography and assembled from his own experience and that of others a considerable body of evidence regarding birds, while he himself speaks for fishes (Jordan, :05). His paper, which appeared in Science a little more than a year ago, contains some extraordinarily sweeping assertions. He says: "....Moritz Wagner (1868) first made it clear that geographical isolation (räumliche Sonderung) was a factor or condition in the formation of every species, race, or tribe of animal or plant we know on the face of the earth." The principles set forth by Wagner "have never been confuted,[1] scarcely even attacked, so far as the present writer remembers, but in the literature of the present day they have been almost universally ignored." The question is much discussed whether minute variations may serve to establish a new species in the presence of a parent species, or whether wide fluctuation or mutation may do so. "In theory either of these conditions might exist. In fact both of them are virtually unknown. In nature a closely related distinct species is not often found quite side by side with the old. It is simply next to it, geographically or geologically speaking, and the degree of distinction almost always bears a relation to the importance or the permanence of the barrier separating the supposed new stock from the parent stock." "The contention is not that species are occasionally associated with

[1] See the works of Darwin ('72), Romanes, Weismann ('72), and Nägeli cited in the Bibliography. Weismann's paper relying upon the case of *Planorbis multiformis* in the Steinheim chalk should be considered in connection with Hyatt's Memoir on the same form ('80).

physical barriers, which determine their range, and which have been factors in their formation. It may be claimed that such conditions are virtually universal. In a few cases, a species ranges widely over the earth, showing little change in varying conditions and little susceptibility to the results of isolation. In other cases, there is some possibility that saltations, or suddenly appearing characters, may give rise to a new species within the territory already occupied by the parent form. But these cases are so rare that in ornithology, mammalogy, herpetology, conchology and entomology, they are treated as negligible quantities. In the distribution of fishes the same rules hold good, but as the material for study is relatively far less extensive and less perfectly preserved than with birds and insects, we have correspondingly less certainty as to the actual traits of species and subspecies, and the actual relation of these to the intervening barriers."

President Jordan summarizes the distribution of species in a law, as follows: "Given any species in any region, the nearest related species is not likely to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort." That the intent of the law involves both animal and vegetable kingdoms seems clear from the context.

President Jordan says that his conclusions, much as they differ from *a priori* judgments or the results of experiment, are the unavoidable outcome of the study of distribution, and that they are as a matter of fact "accepted as self-evident by every competent student of species or of the geographical distribution of species."[1]

Taking the facts of animal geography as they appear in these several essays, typical of a larger number which might be cited, we may say that as a whole they militate against the operation of Mutation in any wide sense in the animal kingdom. This conclusion is not prompted by the attitude of certain of the zoölogists mentioned, who seem to have made but a cursory study of

[1]In a later note in *Science* (N. S., **22**, p. 873) Pres. Jordan modifies his position somewhat, as regards the exclusive agency of spatial isolation and the need of actual physical barriers; but his representation of specific distribution in the animal kingdom is not recast.

the Mutation Theory, but is drawn from the geographic evidence. It is, however, true that the evidence is rather scanty. Moreover there are some exceptions to the general law of distribution, and if these exceptions should, upon further research become very numerous, the prejudicial force of the law would be much diminished. But from the evidence at hand we may infer the very general truth that animal species are distributed according to Jordan's law of geographic isolation; that when exceptions occur, the exceptional species are taken over into some other category of isolation. The nearly universal patch-work character of specific chorology — as at present depicted in the works of zoölogists — strongly suggests the gradual spreading out of individuals over the surface of the earth, their settlement here and there in isolated districts or topographically distinct stations, where shielded from promiscuous intercrossing they have undergone transformations, which have been different in the different areas; transformations which, advancing by whatever forces or conditions, whether those of Natural Selection or of orthogenesis, or what-not, have advanced with even front. This suppositious history is that which forms itself in the imagination of most students of animal geography and has appealed most strongly to me as I have reviewed the literature of the subject.

The Distribution of Plants.

Turning now to the vegetable kingdom we find, first, that there have been few or no exhaustive essays dealing with the question of specific distribution in relation to the theory of evolution. In the second place, it may be said at once that when botanists have turned their attention in this direction their views generally do not coincide with those of the zoologists as to the nature of the facts.

Nägeli ('73) opposed Wagner in a paper of which the purport is succinctly expressed in the title, "Die gesellschaftliche Entstehung neuer Spezies," — the social origin of new species. This eminent botanist stoutly opposed Wagner as to the general character of specific distribution, to the study of which he gave much time in the field for several years. He calls particular attention

to the association of species of plants and their varieties upon the same ground, and states that when one form replaces another in consequence of change of ecological conditions within the same district, the replacing form is not related to the other in the closest grade of affinity, but in some degree more remote. He clearly recognizes the intimate relation of distributional studies to the question of evolution.

There is a little bit of evidence from Wallace (:00, p. 391). He says he made inquiries of two experienced English botanists to find whether well-defined varieties occupy areas to the exclusion of the type and do not occupy the area or only a very small one with the type. Only one such case was found in England. Wallace's conclusion is that such varieties of plants occupying considerable areas to the exclusion of the type are not common.

Asa Gray ('59, p. 193) expressed the following opinion: "Whether capable of scientific explanation or not it is certain that related species of phænogamous plants are commonly associated in the same region or are found in comparatively approximate areas, however large, of similar climate."

The case of *Draba verna* L., is most interesting. As is well known, about two hundred distinct species, or at least kinds, of Draba have been distinguished within the limits of the original Linnæan species *Draba verna*. These numerous forms were studied in cultivation by A. Jordan, and later by De Bary and F. Rosen. They are found to come true to seed, and for this reason are by these authorities spoken of as species. Their geographic distribution is discussed by both Jordan ('73) and Rosen ('89, p. 613). The conclusion is that as a rule the forms which resemble each other most are found in the same stations. The joint occurrence of next related species is indeed a fact which particularly impressed both of these writers. Rosen thinks that it is very unlikely that these closely related species originated separately and by chance came to be associated in the fashion in which they are now found. Such an explanation might serve, he says, if one or two cases only were to be explained; but it becomes absurd when we consider that the concomitance of next related forms is wide-spread. Rosen ends his account of this group of Draba species with a very clear statement of the mutative origin

which he is obliged to assign to these forms; without, of course, using the terms of the Mutation Theory, which he partially anticipates by several years. "The Erophila [Draba] species owe their existence to the free variation of their forefathers. This consists not in a mere heightening or further development of single characters, but variation fashions new characters and combines old characters in new ways. Therefore the forms which arise from species do not intergrade."

He says that, while Selection plays no part in the origin of these forms it operates upon them after they appear. And of the laws which must control this sort of variation he speaks as follows: "Variation is not blind, vaguely working in all directions, but is obviously determined by laws unknown to us: for we are obliged to assume that the same or similar combinations of next-related forms have arisen in different places. But what can these laws be?" It is most interesting and significant that *Rosen is led to these de Vriesian conclusions through floristic and geographic studies.*

The following excerpt from A. Jordan ('73, p. 4) has so direct a bearing upon our argument that I give it entire: "Ayant observé dans leurs stations diverses, pendant plus de trente années, une foule de végétaux de toutes les familles et de toutes les catégories, des plantes annuelles ou vivaces, bulbeuses ou aquatiques, des arbres ou des arbustes, j'ai pu constater presque partout que lorsqu'un type linnéen, vraiment indigène dans une contrée, y était commun à ce point qu'on pouvait le citer parmi les plantes caractéristiques de la végétation d'une certaine étendue du territoire, ce type y était presque toujours representé par des formes diverses, plus ou moins nombreuses, *croissant en société et pêle-mêle* [ital. mine]. L'observateur superficiel, qui parcourt le terrain, n'est frappé que des ressemblances de ces diverses formes; il n'aperçoit pas leurs différences, ou, n'y attachant aucune importance, il ne s'arrête pas à les considérer attentivement; il croit n'avoir affaire qu'à un type unique, susceptible de quelques modifications accidentelles et sans valeur. Tandis que celui qui observe avec attention peut aisément se convaincre, sur les lieux, que ces modifications apparentes se retrouvent sur des individus divers, tous parfaitement semblables entre eux. Si,

pour pouvoir continuer et compléter son observation, il arrache des pieds vivants de chacune des formes qu'il a pu distinguer et les replante ensuite, dans un même lieu, afin de les suivre dans tous leurs développements, il se convaincra bientôt qu'elles présentent des différences appréciables, dans tous leurs organes S'il sème leurs graines, il les verra se reproduire avec une parfaite identité de caractères.

"Voilà le fait que j'ai pu constater moi-même mille fois, que j'ai fait constater dans les lieux que je ne pouvais visiter, en France, en Corse et en Algérie ou ailleurs, par divers botanists qui m'ont envoyé soit des graines, soit des pieds vivants de formes nombreuses, recueillis dans les mêmes station et appartenant aux memes types linnéens. Je ne dis pas que les plants communes soient toutes également et partout diversifiées. Il y a, sous ce rapport, de grandes differences entre elles. Je dis seulement que *le cas où elles présentent diverses formes croissant en société est le cas le plus ordinaire* [ital. mine], et je crois que ce fait paraîtra clair, patent, indiscutable, à quiconque prendra la peine de le vérifier sérieusement."

In the literature of this subject, as far as I have read it, essentially the only writers who insist on the isolation of nearly related kinds of plants are the zoologists. Their assertions are not, however, supported by evidence from the vegetable realm.

I have examined the distribution of North American Orchidaceæ from the standpoint of this paper. Furthermore, I have consulted with several specialists in different groups as occasion offered. Several members of this club have given me information with permission to publish it along with the evidence gathered by myself. I may take the groups in sequence.

For Algæ, Mr. F. S. Collins speaks as follows in regard to their general distribution and in particular the distribution of nearest related species: "As regards fresh water algæ, it almost seems as if geographical limitations did not exist. Of course this is not entirely true, but the area of distribution in the case of the great majority of fresh water algæ is vastly greater than in the

case of most flowering plants.[1] The limitations seem to be those of temperature, exposure, character of attachment, and to a less degree, geological characters. Take the genus Vaucheria, for instance. The last serious work is by Götz; a study of the species of Vaucheria in the neighborhood of Basel, Switzerland. There are 12 species there; 8 of them occur in England, 6 in the New England States, 7 in California. Only three other fresh water species are recorded for North America; one is a European species, found in the West Indies but not elsewhere so far on this continent; the other two are from California. Now these two species, growing together, belong to the same subgenus, and I know of no described species that I should say belonged in between them. Take the genus Spirogyra. The best book on this is that of Petit, Spirogyres des Environs de Paris. He includes 37 species; of these 34 have been found in North America. We have also five other species; three of them are European, though not found about Paris; the two others are from Greenland and Florida respectively. It is much the same with all the fresh water algæ; of the very inconspicuous species, the records from distant stations are not so abundant, but that is largely because these minute forms have been little studied outside of Europe.

"As to the marine algæ, the difference geographically is much greater. It would seem strange that marine algæ on the two sides of the Atlantic, should differ much more than the fresh water algæ of the two continents, but such is the fact. Still the resemblances are much greater than with flowering plants. And there are many instances where closely allied species or varieties have practically the same range. I will give a few such pairs, and in each case there seems to be no species or variety anywhere else that would stand between the two in question.

"*Cladostephus verticillatus* and *C. spongiosus* have the same range, in temperate waters on both sides of the Atlantic. They are the only species of the genus in that range. *Fucus edentatus* and *F. evanescens* have their headquarters in high arctic regions,

[1] Compare Alph. De Candolle, Geographie Botanique, **1**, p. 499: "Nous arrivons ainsi à une loi importante, savoir que *l'aire moyenne des espèces est d'autant plus petite que la classe dont elles font par ie a une organisation plus complète, plus développée, ou, selon l'expression usitée, plus parfaite.*"

extending to Great Britain, New Jersey and California. *Myriotrichia filiformis* and *M. clavæformis* have practically the same range as the Cladostephus species. *Ralfsia borneti* and *R. verrucosa* have a slightly more northern range on both sides of the Atlantic. *Phyllophora brodiæi* and *P. membranifolia* range from France and New Jersey to Norway and Labrador. *Polysiphonia violacea* and *P. fibrillosa* from Virginia to Maine, from the Mediterranean to Scotland. *P. harveyi* and *P. olneyi* are American species, or possibly varieties of the same species; they have the same range as *P. violacea* and *P. fibrillosa*; wherever I found one, I should expect to find the other.

"I could keep on for some time in this way, but will give only one more instance; that is a group of species in the genus Antithamnion, one of the most beautiful of the red algæ. On the European coast *A. plumula* ranges from Morocco to Great Britain; *A. cruciata* about the same; *A. floccosa* from the English channel to high arctic regions; *A. boreale* from the Faroes north; *A. pylaisæi* from Norway north. On the American coast *A. plumula* and *A. cruciatum* range from New Jersey to Cape Cod; *A. floccosum* and *A. boreale* from Cape Cod to Greenland; *A. pylaisæi* from Long Island Sound to Greenland; *A. americanum* from New Jersey to Portland, Maine. On our Pacific coast *A. floccosum* ranges from California to Alaska; *A. boreale* from southern Alaska to high arctic regions; *A. pylaisæi* from Washington north. Now these are all so closely allied that Rosenvinge some time ago proposed to unite them all under the older name, *A. plumula*. He is a man with a strong tendency toward uniting, it is true, and has since concluded that *A. cruciatum*, and possibly *A. floccosum* are distinct; but at any rate, this shows how closely allied they are.

"Some things about algæ seem very much like supporting the mutation theory; when the same species occurs in widely distant stations, we sometimes find with the type exactly the same varieties and forms."

Dr. Evans, while lacking the opportunity to pay very extended attention to the subject, has given me the following indication of the distributional conditions in Hepaticæ. "One of the best examples of a cognate pair of species is *Leptolejeunea elliptica*

and *L. exocellata*. The first of these species is very widely distributed in tropical America, growing on the upper surface of thick and glossy leaves. The second species is less abundant but nearly always occurs mixed with the first.

"Among northern species *Lophozia barbata* and *L. lyoni* are closely related and often grow together, although each retains its distinctive characteristics. The same is true of *Gymnomitrium concinnatum* and the much rarer *G. corolloides*; of *Sphenolobus exsectus* and *S. exsectæformis;* of *Anthoceros levis* and *A. punctatus*.

"As a group of related species I might mention the ventricosa-group of the genus Lophozia. This contains about half a dozen closely related species, most of which are circumpolar in their distribution. *L. ventricosa*, *L. alpestris*, *L. porphyroleuca*, *L. longidens* and *L. confertifolia* are all known from New England, being most abundant in mountainous regions. Of these *L. porphyroleuca* and *L. longidens* grow on rotten logs, and the others on moist rocks, although *L. longidens* is equally at home on either substratum. Although I have no definite data that these species actually grow mixed in North America, their ranges coincide to a greater or less extent with some overlapping.

"Unfortunately our information is not very full at present about the distribution of many species. Only a few regions have been at all accurately studied, and I feel sure that further study would considerably lengthen the short list I have given."

Mr. A. A. Eaton has given me several examples from Equisetum and Isoetes. "*Equisetum fluviatile* is circumboreal in its distribution. No third form stands between this and *E. palustre*, yet the latter has practically the same range. *E. scirpoides* and *E. variegatum* are a cognate pair, and yet both have in general the same range throughout the northern part of both hemispheres. *E. variegatum* has a variety, *E. variegatum jessupi*, distinguished by anatomical characters. Its range, Vermont to Minnesota, is quite covered by that of the species. *E. lævigatum* has a near relation, without an intermediate, in *E. hiemale intermedium*, and this on the other side is next to the variety *affine*. The last of the trio is wide-spread in northern North America and overlies the other varieties, which also essentially coincide in their ranges. *E. arvense* is found in Europe, Asia, N. America to Virginia and

southern California. Its near of kin (without intermediate), *E. telmateia*, is found with it (broadly speaking) in Europe and California. Starting with *E. pratense* a next-related species is *E. sylvaticum*. The former belongs to northern Europe, Siberia, Alaska, Canada, the Rocky Mountains, Labrador, and southward to Massachusetts and New Jersey. The other is circumboreal, covers the range of the first and with us goes somewhat further south to Virginia.

"In Isoetes we find the following coincident ranges of close relatives. *Isoetes tuckermanni* is found quite plentifully in New England and completely overlies the range of its varieties *harveyi* and *borealis*. *I. Engelmanni* is found plentifully throughout the region east of the Appalachian range, from New Hampshire and Vermont to Pennsylvania, extending sparingly to Georgia. It overlies the ranges of its varieties *caroliniana*, *fontana* and *valida*. *I. canadensis* is found from Pennsylvania to Maine and Quebec, appearing again in British Columbia. Its next of kin in the genus is *I. engelmanni*, whose range for the most part it covers, and the two species are not rarely found commingled in the same pond. *I. bolanderi* is found from Wyoming to California and Washington. Its next of kin would appear to be *I. pygmæa* of the Mono Lake region of California, and the two species were found by members of the King Expedition in contiguous areas. It may be supposed that *I. pygmæa* is an abnormal form of *I. bolanderi* and hence not competent in this relation, but the next of kin of *bolanderi* is *I. echinospora* var. *braunii*, which overlies the range of *bolanderi*, but is widely distributed otherwise in North America."

I have inquired of President Brainerd about the conditions in Viola, and particularly whether pairs of closely related species are found within the same ranges. He answers: "Many pairs of species in Viola closely allied and nearly co-extensive in range are to be found." He mentions six of them; viz. (1) *V. fimbriatula* and *sagitata*, (2) *V. palmata* and *papilionacea*, (3) *V. septemloba* and *emarginata*, (4) *V. lanceolata* and *primulæfolia*, (5) *V. ranifolia* and *incognita*, (6) *V. arenaria* and *conspersa*. These are without intermediate species says President Brainerd, but they have intermediates resulting from hybridization, found in the same localities with the species.

To Professor Charles Sprague Sargent I am indebted for interesting information as to the distribution of North American Cratægus. As is well known, numerous species have been distinguished within the last few years, of which some five hundred have been named. These species are readily and unmistakably recognized by special students of the genus, by means of floral characters such as number of stamens, color of anthers, form of inflorescence, etc.; by fruit characters, configuration of nutlet, time of blooming and fruiting, character of foliage, veining, presence or absence of hairs, etc.; traits which appear to be constant and reliable as shown by extended observation in the field and by cultures of seedlings carried on now for a number of years at the Arnold Arboretum. In these cultures, the sowings from the several species result in crops of seedlings of remarkable uniformity within the limits of each species, and in the instances in which the seedlings have flowered and fruited, of notable conformity to parental type. This result must certainly diminish the scepticism with which the proposal of such a vast number of species within the one genus has rather naturally been met in some quarters.

In answer to the question whether the nearest related species are separated, as the law of D. S. Jordan and of Wagner would require, Professor Sargent replies in the negative.

In the genus as it is represented in North America several groups are distinguished, which in part correspond to the species of the older writers, and which may be readily recognized by anyone with a little attention· such are Crus-galli, Punctatæ, Æstivales, Tenuifoliæ, Pruinosæ, Intricatæ, Flabellatæ, Anomalæ, Molles, Tomentosæ, etc. These groups are in general fairly well restricted to particular geographic sections. For example, the Tenuifoliæ, the largest group in the northeast, do not extend west of the Mississippi river, or go southward except along the mountains. The Flavæ are found only in the southeast. The Intricatæ are most numerous in eastern Pennsylvania, extending along the mountains southward to the end of the Alleghanies, northward into Vermont, and westward through New York and Ontario to southern Michigan, within which distributional area they mingle with all the other northern groups. In some cases a group

predominates in a region, in other regions several groups are nearly equally represented. Within each group, divisions can be made; but in the case of these divisions geographic separation does not obtain, since species of all the divisions of a group are likely to occur in any part of the general territory proper to the whole group. Regarding the ultimate units, or species, those which are most closely allied are likely to be found promiscuously associated in the same district and without the semblance of isolation. For example species of the Pruinosæ or of the Intricatæ with 10, or with 20 stamens, or with rose-colored, or with yellow anthers are found growing within a few feet of one another, and may cover common districts of several hundred square miles. In these cases, while it is the number of stamens or color of anther which first attracts attention, other specific characters exist which adequately distinguish the species. As an example of promiscuous association, the vicinity of Albany may be pointed out, where the five species of Intricatæ heretofore found in New York state grow in a small area. In Ontario we find twenty-five species of Tomentosæ, many of them growing very close together. In the distinctly southern group Microcarpæ we find the two species, *C. apiifolia* and *C. spathulata*, growing over the same areas, while the third and more distantly related species, *C. cordata* has a somewhat more northern range. In general, the reverse of Jordan's law would more nearly represent the distribution of American species of Cratægus.

Coming now to Orchidaceæ, I may say that I adopted the line of examination suggested by the form of Jordan's law; that is, I looked for pairs of kinds. I say kinds instead of species intentionally. The main problem should not be confused by the difficulty of agreeing upon a definition of species. What the evolutionist has to account for is not the definitions of systematists, but the multiplicity of hereditary types; he has to explain the antithesis between the uniformity which heredity seems at first to promise, and the diversity which actually prevails among organic things. A definition of species is demanded in taxonomy, but is somewhat less necessary in studies like the present. We do not require that the forms be related in some particular taxonomic sense; but only that they have different hereditary charac-

ters. In order to avoid complications I have used the word *kind* to designate such different types, instead of the words species, variety, etc., which have restricted technical senses.

I have sought for closely related pairs of kinds so made up that in each case no third kind stands between the members of the pair in resemblance. Such pairs I may call immediately cognate pairs, or for short, cognate pairs. A pair may consist of two species, two varieties, two subspecies, a species and a subspecies, a species and a variety, etc. It is assumed that such cognate pairs represent recent forkings of the phylogenetic tree; and that if we could collect all such cognate pairs in the vegetable kingdom we should have a representation of all the youngest forkings. Evidently their distribution would be very illuminating, for the youngest branches are on the average the least disturbed geographically, and the distribution of the members of these pairs would represent as accurately as we could ever discover it, the position of things at the moment when forking takes place. That is, we should have a geographic chart, more or less distorted it is true, of the origin of kinds. If the members of the pairs are universally, in the vegetable kingdom, separated from each other, then — as already explained — Mutation is excluded as a true cause of diversification of hereditary types in plants. For among several forms of isolation to which Mutation may conceivably give rise, and which are, therefore, not inconsistent with the mutational assumption, the one form of isolation to which it could never give rise is geographic isolation.

I repeat that I have examined only the broad geographical aspect of distribution and not at all the topographical, for which exact data are wanting. Let the reader recall the two stages of this general inquiry: my evidence belongs to the first of these. I present the following facts as a contribution towards an answer to the question, Is Mutation instantly excluded from a place among the considerable powers in evolution, by the broad aspects of specific distribution in plants? I have taken only one step. But this may be of some little importance, especially in view of the assertions concerning the distribution of plants which have been made, and in view of the lack of even broadly geographical statistics.

The American Habenarias have been given careful study in our laboratory. In addition to our own collections, those from several of the largest herbaria in the United States have been brought together. The species have been delimited with minute attention and then the distribution of each species, represented by the large amount of material assembled, has been recorded. Thus exceptionally full and reliable returns have been secured, which are available for the present paper.

H. ciliaris R. Br., and *H. blephariglottis* Torr., are a pair of perfectly distinct, yet extremely similar species. While instantly distinguishable in the field by their colors — the flowers of the former being yellow or orange, those of *H. blephariglottis* pure white — the dried specimens are separated only upon close inspection. The best distinguishing character is then the degree of fimbriation of the lip, which is considerably greater in *H. ciliaris* than in *H. blephariglottis.* No third species stands between them. They are spread together through the eastern United States. *H. ciliaris* is found in Massachusetts, Connecticut, New York, Ontario, Michigan, New Jersey, Pennsylvania, Ohio, Indiana, Delaware, Maryland, District of Columbia, Virginia, Kentucky, North Carolina, Tennessee, Missouri, Arkansas, S. Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas. *H. blephariglottis* is found in Newfoundland, Nova Scotia, New Brunswick, all New England, New York, Ontario, Michigan, New Jersey, Pennsylvania, Ohio, Virginia and North Carolina; and if we include the southern form which may possibly be distinguished, the range is extended to South Carolina, Georgia, Alabama, and Mississippi. Whether we allow that the southern form is distinct or not is immaterial, since it does not stand between *H. blephariglottis* and *H. ciliaris,* and the latter species covers the range of both the northern and the southern forms of the other.

H. cristata R. Br., *H. chapmanii* Ames, and *H. ciliaris* R. Br., form a group of very closely related kinds. *H. cristata* is like a very small *H. ciliaris,* with a broader and un-clawed lip, petals oblong or somewhat obovate instead of linear, and a spur

shorter than the ovary instead of longer. *H. chapmanii* is intermediate between the others in perhaps every respect, and this fact, with the absence of any new character of its own, makes this species appear very like a hybrid. Its apparently local occurrence is in favor of hybridity. But allowing it to be independent, it forms a pair with *H. cristata* on one side, and with *H. ciliaris* on the other. On the other hand, removing the plants now grouped as *H. chapmanii*, because of suspected hybrid origin, we have left a very close pair in the two supposed parental types. On any disposition of the matter, the geographical ranges of the three kinds are found to coincide widely. The range of *H. ciliaris*, as above shown, extends from New England to middle Florida and Texas, and inland to Michigan, Missouri and Arkansas. That of *H. cristata* includes all the Atlantic states from New Jersey to Louisiana, with Pennsylvania, Tennessee and Arkansas added. Specimens of *H. chapmanii* have been seen only from northern Florida.

Habenaria psycodes Gray, and *H. fimbriata* R. Br. are a very close pair, with no intermediary. They are with some difficulty distinguished, yet statistical studies that I made upon them some time since convinced me that authors, including the most reliable authorities, are right in considering them specifically distinct. No one character can be relied upon to separate them invariably but all characters of each species fluctuate, so that any given part in one may run into the form characteristic of the other species. The balance of characters, however, is almost always decisive. The geographic ranges are very largely the same. Both are found in Newfoundland, Nova Scotia, New Brunswick, Quebec, all New England, New York, New Jersey, Pennsylvania, and North Carolina. *H. psycodes* extends further west, and *H. fimbriata* a little further south, as represented in the collections before me.

H. peramœna Gray, has for its probably nearest relative *H. fimbriata* — or possibly *H. psycodes* — with no species between. The three species mentioned, with *H. leucophæa*, form a group of close affinity. While *H. peramœna* is more widely distributed westward and southward (Ill., Mo., Ala.), and *H. fimbriata* much further northward, they occupy extensive territory together; *viz.*,

Pennsylvania, West Virginia, North Carolina, and Tennessee. If *H. psycodes* is substituted for *H. fimbriata* in the comparison, the geographic result has the same influence on the discussion.

H. orbiculata Torr. and *H. macrophylla* Goldie are so close that the plants of the two kinds have long been accepted by collectors and described by authors as of one species. The differences are at first sight slight, but are apparently constant and sufficient for distinction. The former species has a much greater range, which completely covers that of the latter. *H. orbiculata* extends from Labrador and Newfoundland westward through Michigan, and Minnesota, to British Columbia and Washington; and southward through New England, New York, and Pennsylvania to South Carolina and Tennessee. It is found in every district where *H. macrophylla* is found; viz., Newfoundland, New Brunswick, Ontario, Michigan, New England, and New York. The status of these two species is discussed by Ames in *Rhodora* for January, 1906, with illustrations of the flowers.

The difficult genus Spiranthes has lately been thoroughly studied by Ames, who has given the results in Orchidaceæ, Fasc. I, pp. 113–154. The abundance of material examined may be seen from the citations of specimens in the detailed statement of the distribution of each species.

S. cernua Rich. has for nearest allies, first, the variety (which some authors regard as a species), *S. cernua* var. *ochroleuca* Ames, and secondly the species *S. odorata* Lindl. *S. cernua* may be paired with either of them. *S. cernua* and *S. cernua ochroleuca* in the dried state can be separated with certainty by no macroscopic character. They may be distinguished by the seeds, however, *S. cernua* being polyembryonic.[1] Unfruited specimens being indistinguishable in the dry state, the exact distribution of each form may not be very precisely defined, but Rydberg in Britton's Manual gives the range of var. *ochroleuca* as from New Hampshire and Massachusetts to Pennsylvania and North Carolina. I myself have identified, as being unmistakably typical *S. cernua*, specimens from Massachusetts, Ontario, Iowa, and Georgia.

[1] See my notes on the embryology of the two forms in Rhodora **2**, p. 227 (1900) and **3**, p. 61 (1901). In *S. cernua* embryo formation takes place without pollination.

Thus the range of the species overlies that of the variety. Geographic isolation is wanting.

When we compare *S. cernua* with *S. odorata* we find again a very strong likeness. *S. odorata* is usually much larger in all parts than the former. The length of the scape relative to that of the leaves is greater in *S. odorata*, and its leaves are less strictly radical. Those not expert in the genus Spiranthes would often distinguish the two species with difficulty. They might be regarded as elementary species in de Vries's sense. *S. odorata* has been found in Virginia, Georgia, Florida, Alabama, Louisiana, and Texas, and its range thus coincides widely with that of *S. cernua*.

S. romanzoffiana Cham. and *S. porrifolia* Lindl. are very closely related species, which no other species approaches. The former is by very much the more widely dispersed, since it crosses the continent, while *S. porrifolia* is confined — according to specimens seen — within the states of Washington, Oregon, and California. *S. romanzoffiana* is represented in our records by many specimens from these same states, and there is therefore no general geographic separation in this case.

S. laciniata Ames and *S. vernalis* Engelm. and Gray are extremely similar but distinct species. The former is confined to Georgia, Florida, Alabama, Louisiana and Texas. *S. vernalis* occurs in all these states, but reaches far beyond this area.

S. beckii Lindl. and *S. gracilis* Beck are an immediately cognate pair of near affinity. The former grows in the Atlantic states from Massachusetts to Texas. *S. gracilis* covers the same range, but is also to be found further north and further inland. There is no geographic isolation.

Cypripedium pubescens Willd. and *C. parviflorum* Salisb. have had attention at this laboratory for several years, observations having been made in the field and in the herbarium, and collections of dried specimens having been received from many sources. Measurements indicate that there are two pronounced tendencies as regards size of flower. In life, the plants generally have an appearance of distinctness, and most field naturalists whose opinions have been asked, have maintained that the two kinds are specifically different. The manuals treat them so. Yet they

occasionally intergrade and perhaps can be regarded merely as subspecies. I have found them growing together in closest proximity. We have specimens of *C. parviflorum* from Ontario, British Columbia, New England, New York, New Jersey, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, Washington; and of *C. pubescens* from New England, New York, Pennsylvania, Ohio, Illinois, Wisconsin and Minnesota. The manuals extend the reported occurrence of both plants to Georgia. Thus the ranges of these two very closely allied kinds coincide over a very wide extent of territory. No other form in the world stands between them.

The genus Calopogon is confined to the eastern half of the United States (if we except the occurrence of *C. pulchellus* in Cuba), and comprises four close species and a variety, or five species. These species all come together and overlap in Florida. One, *C. pulchellus* R. Br., ranges from Newfoundland to Florida, Cuba, and Missouri, and geographically includes all the rest. *C. pallidus* Chapm. ranges from North Carolina to Florida and Alabama; *C. parviflorus* Lindl. from North Carolina to Florida; *C. multiflorus* Lindl. is confined to Florida. Here, therefore, are several pairs of cognate species not geographically separated.

Pogonia verticillata Nutt. and *P. affinis* Austin make a pair of very nearly related yet distinct species. The former extends from New England to Florida and west to Wisconsin and quite surrounds the other, a very rare species occurring sporadically in Vermont, Massachusetts, Connecticut, New York and New Jersey. Here again geographic isolation is wanting.

The conclusion from this examination of North American Orchidaceæ is that cognate pairs of kinds with uniform or widely coincident ranges are too numerous to leave any force at all in Jordan's law in its broad sense as regards this family in our flora. If one member of each pair was derived from the other member, or both were derived from a parent species, then, *as far as the geographic evidence goes, the new species may have originated in the same district with the old one; i. e. without geographic isolation.*

Concluding Remarks.

In concluding this paper I may make some remarks of a general character touching the whole problem.

First, we note that zoologists and botanists are rather distinctly opposed to each other in their views of the actual state of specific distribution. The suggestion is offered that zoologists may best discover the condition and interpret its meaning among animals, and botanists among plants. In no case is it safe to reason deductively from one kingdom to the other. In the factors affecting their evolution plants and animals differ vastly.

Secondly, in seeking for the laws of specific distribution we should first take the facts as we find them. We should agree to consider that in the absence of explicit evidence to the contrary, kinds now found in coincident ranges have been so situated from the beginning. In any given cases this assumption may or may not represent the truth, but we have no right to postulate movements in the past, of which there is no certain evidence, in order to save a preconceived theory. We may call such hypothetical migrations into being, in a strictly limited number of cases, upon a reconsideration, if from a first examination of the unmodified facts some law emerges so strong and compulsory that the few exceptional instances must somehow be brought into accord with it.

In the third place, if I may express my personal impression of the matter with regard to plants, it seems to me that the study of specific distribution in the vegetable kingdom is not likely to be unfavorable to Mutation, regarded as a method, but perhaps not the sole method, of evolution. It is true that in examining the distribution of species of plants, one encounters an effect which seems to be connected with geographical distance. We often find that a species of wide distribution exhibits slightly different phases in different divisions of its range. These phases are sometimes too subtle for definition and pass into one another by degrees, yet are evident to students of particular groups. Such cases do not look like the work of Mutation. They exemplify that which, to conceal ignorance of causes, may be termed a geographic effect.

But this aside, the indications seem to me to be that a good many instances sustaining the notion of mutative origin will be found among plants. It is not to be expected that the number of such cases will be *relatively* large. On the assumption of periodic Mutation as the origin of species, with competition between associated mutants and the survival of those mutants best fitted for existence in the original habitat, and the spread of mutants with new capacities into areas or habitats not open to the parental species, we should expect to find as a rule a single species occupying a given territory or ecological footing, and related species in separate, neighboring areas or habitats; though it is evident that mutants instantly endowed by Mutation with physiological or chronal isolation might continue to exist side by side with the parental species or with sister mutants if there were no active vegetative competition between the associated stocks. As a matter of fact, in many species of plants competition for subsistence between individuals of the same parentage is practically absent. Unification of congenital mutants may be brought about by continued interbreeding. This would eventually destroy the geographic evidence of Mutation in any given case. But in such amalgamation the effects of Mutation may not be destroyed; for new characters may during amalgamation be perpetuated in full force. It is single characters, rather than constellations of characters, with which the Mutation Theory is primarily concerned The number of cases of association of closely related species resembling recent mutants, in proportion to the number of cases of geographic or topographic segregation of closely related species would depend upon the balance between the activity of Mutation on the one hand and the operation of the forces tending to isolate or to amalgamate the products of Mutation on the other. If mutative periods are far apart in most species — and stability of the organic world may preclude great frequence — while the segregating or amalgamating powers are constantly at work, then the occurrence of the social condition indicative of Mutation may be expected to be relatively infrequent.

In order to use geographical evidence effectively against the Mutation Theory, its opponents must show that the social condition of closely related forms is, to use President Jordan's words,

"virtually unknown." In the vegetable kingdom this is likely to be an arduous task. The indications are that the adherents of Mutation will be able to bring forward enough cases of social distribution to render phytogeographic weapons useless in the attack upon this Theory.

THE AMES BOTANICAL LABORATORY,
NORTH EASTON, MASS.

LITERATURE

CASTLE, W. E., AND FORBES, ALEXANDER.

1906. Heredity of Hair-length in Guinea-pigs and its bearing on the theory of pure gametes. Published by the Carnegie Institution of Washington, D. C.

DARWIN, CHARLES.

1859. The Origin of Species, chapters 11 and 12, on Geographical Distribution.

1872. The Origin of Species, 6th Edition, chapter 4, as far as it relates to Isolation and to Divergence of Character.

DAVENPORT, C. B.

1906. Inheritance in Poultry. Published by the Carnegie Institution of Washington, D. C.

DE VRIES, H.

1903. Die Mutationstheorie, **2**, pp. 396–457 (die Mutationskreuzungen).

GULICK, REV. J. T.

1887. Divergent evolution through cumulative segregation. Jour. Linn. Soc., Zool., **20**, p. 189.

1905. Evolution, racial and habitudinal. Published by the Carnegie Institution of Washington, D. C.

HYATT, ALPHEUS.

1880. The genesis of the tertiary species of Planorbis at Steinheim. Anniversary Mem. Boston Soc. Nat. Hist. 1880.

JORDAN, ALEXIS.

1873. Remarques sur le fait de l'existence en société, a l'état sauvage des espèces végétales affines et sur d'autres faits relatifs a la question de l'espèce. Lyon, Pitrat Ainé (pp. 23).

JORDAN, PRESIDENT DAVID STARR.

1905. The Origin of species through isolation. Science, N. S., **22**, p. 545. In the same volume, p. 873, appears a note modifying some statements of the above paper.

MACDOUGAL, D. T.
1906. Discontinuous variations in pedigree cultures. Pop. Sci. Monthly, Sept., 1906.

MERRIAM, C. HART.
1906. Is Mutation a factor in the evolution of the higher vertebrates? Proc. A. A. A. S., New Orleans, 1906, p. 383. Also Science, N. S., **23**, p. 241 (1906).

NÄGELI, C.
1873. Die gesellschaftliche Entstehung neuer Spezies. Sitzungsb. d. math.-phys. Klasse d. k. b. Akad. München, **3**, p. 305 (1872–3).

ROMANES, G. J.
1886. Physiological Selection. Jour. Linn. Soc., Zool., **19**, p. 337.
1906. Darwin and after Darwin. Vol. 3, Isolation and physiological selection. Opinions on isolation [with clues to valuable data of distribution]. The appendices contain important matter.

ROSEN, F.
1889. Systematische und biologische Beobachtungen über Erophila [Draba] verna. Bot. Zeit., **47**, pp. 565, 581, 597, 613.

WAGNER, MORITZ.
1889. Die Entstehung der Arten durch räumliche Sonderung. Gesammelte Aufsätze. Basel. This edition contains the following papers of importance: Die Darwin'sche Theorie und das Migrationsgesetz der Organismen. Leipzig, 1868.— Ueber den Einfluss der geographischen Isolirung und Kolonienbildung auf die morphologischen Veränderung der Organism. München, 1870, Sitzungsb. d. k. bayer. Akad. Wiss. 2 July (1870).— Ueber die Entstehung der Arten durch Absonderung. Kosmos, Hfe. 1, 2, 3, (1880).— Darwinistiche Streitfragen [5 papers]. Kosmos (1882, 1884).

WALLACE, ALFRED RUSSELL.
1855. On the law which has regulated the introduction of new species. Annals and Magazine of Nat. History, September, 1855. Also in his Contributions to Natural Selection, London, 1875, p. 5.
1900. Studies, scientific and social, **2**, p. 391.

WEISMANN, AUGUST.
1872. Ueber den Einfluss der Isolirung auf die Artbildung. Leipzig, Engelmann.
1904. The Evolution Theory. Tr. by Thomson. London, E. Arnold. Vol. 2, ch. 32, Influence of isolation on the formation of species. Also **2**, p. 350.

THE COINCIDENT DISTRIBUTION OF RELATED SPECIES OF PELAGIC ORGANISMS AS ILLUSTRATED BY THE CHÆTOGNATHA.

CHARLES ATWOOD KOFOID

No small part of the diversification of the organic world has taken place in the open sea. Whether we accept the view that the littoral and abyssal faunas are derivatives of the pelagic, or regard the latter as secondarily derived along many lines from the organisms of the shore and bottom, the fact remains that many groups have undergone great diversification both in the specific and in higher categories in the pelagic habitat. Illustrations of this process are to be found in the diatoms, the Protozoa (notably the Foraminifera, Radiolaria, Dinoflagellata and Tintinnoina), in the Scyphomedusæ, Siphonophora, and Ctenophora, Ostracoda, Schizopoda, Amphipoda, Decapoda, Heteropoda, Pteropoda, Cephalopoda, and Tunicata and certain families of fishes. The Nemertini, Annelida, Rotifera, Holothuroidea and the Hemiptera are sparingly represented. One class, the Chætognatha, are exclusively marine and pelagic, and their affinities are with the more primitive types of invertebrates. It seems probable that their entire evolution, or at least their generic and specific differentiation has taken place in the marine habitat. Their present distribution is therefore of prime interest because of its bearing on the relation of isolation to the origin and preservation of species.

Barriers are far less in evidence in the environment of the pelagic fauna than in that of the shore or of the land. A few instances in limited regions along the margins of great ocean currents as, for example, along the edges of the Gulf Stream or in horizontally stratified waters, there are abrupt transitions in temperature, but in the main the changes in temperature, illumination, density, and substances in solution or suspension, are so gradual that zoological provinces are delimited with difficulty and mainly in terms of temperature, on the high seas away from the influence of

shore conditions. In a large and somewhat vague way isotherms and isothermobaths constitute the barriers of the sea. Many, and in some groups, most of the pelagic species are wide-ranging, found in most seas, through a greater or less range of temperature. The pelagic fauna has thus a considerable cosmopolitan element and part of the differences which result in the contrasted poverty and richness of pelagic fauna are due to changes in the *numbers of individuals* and in the proportionate representation of the various components, as much as, or even more, than to *restrictions in the distribution of species*. In so far as the species of any group of related organisms establish themselves throughout a wide, coincident or overlapping range, in like degree isolation becomes problematical as a factor in the origin of new or preservation of old species.

Our knowledge of the horizontal and vertical distribution of pelagic organisms is lamentably incomplete and partial, and no less so of the Chætognatha than of other groups. Fowler (:06) calls attention to the fact that he finds no published record of a single *species* of that group between 160° E and 80° W, nearly the whole of the Pacific Ocean! Unfortunately no report was published on the Chætognatha of the Challenger Expedition and the results of later surveys have not yet appeared. We find, however, an excellent summary of the known distribution in Fowler's (:06) report on the 'Siboga' collections, based largely on his Biscayan investigations, Fowler (:05), and the work of Doncaster (:03) on the Maldive and Laccadive fauna, of Aida ('97) on that of Japanese waters, of Steinhaus ('96) and Strodtmann ('92) on collections from the Atlantic, and of various recorders in the lists of the *Conseil permanent pour l' exploration de la Mer*, from the waters of Northern Europe. The data thus assembled by one whose critical knowledge of the species has enabled him to sift out synonyms and eliminate probable errors, are far from being adequate to give a complete or satisfactory presentation of the distribution of Chætognatha in the seas named. They are, nevertheless, of sufficient fulness to afford a basis for the consideration of the extent to which isolation of species prevails in this typical pelagic group of organisms and to mark out clearly the necessity for additional data on vertical distribution and breeding seasons for a critical and final analysis of the problem.

It is the purpose of the present note to call attention to the important contributions which investigators of pelagic life might make to the discussion of this phase of the problems of evolution especially since monographers of pelagic groups are best qualified to judge of the degrees of affinity between the species of the genus and can determine whether the most closely related ones have a coincident or contiguous distribution. It is exceedingly desirable that future expeditions investigating the life of the high seas be equipped for a fuller analysis of the details of vertical distribution and that data on breeding seasons of pelagic species be included in monographs whenever available.

Genus Krohnia

This genus includes three species, *K. hamata*, *K. subtilis*, and *K. pacifica*. The first are two oceanic species of wide distribution, the last an Indo-Austral species of surface neritic distribution. The horizontal area of distribution of the first two species is largely coincident, *K. hamata* being known to extend to higher latitudes (81° N., 52° S.) than *K. subtilis* (60° N., 29° S.). As might be expected from its temperature relations, *K. hamata* is recorded from lower levels in the tropics than is *K. subtilis*. Data on this point are not very complete as *K. subtilis* is not an abundant species. The closing net catches of the Plankton Expedition indicate a maximum depth of 1500 m. for *K. hamata* and 850 m. for *K. subtilis*. The two occur together between 300 and 500 m. (37° N). The extent to which the vertical distribution of the two species overlaps cannot be determined from the available data. Fowler (:05) shows that the size of the individual of *K. hamata* increases with the depth in the Biscayan region. The young, that is, only small specimens, were taken above 500 fathoms and large ones with occasional small ones below that level. The sexual condition at different levels was not noted. The possibility of overlapping distribution is certainly present but contiguous distribution is by no means excluded.

Krohnia hamata is found in the mesoplankton of the Indo-Austral region, where *K. pacifica* is also found, but in surface waters exclusively. These two species were thus contiguous

rather than coincident in their distribution. There is thus little conclusive evidence of coincident distribution in the few species of *Krohnia*.

GENUS SPADELLA

The case of the two species of Spadella, *S. cephaloptera* and *S. draco* the area of distribution of the latter, which is a wide one, includes that of the former which is a neritic species from the northwestern coasts of Europe and the Mediterranean. They are both surface forms and their distribution is of the coincident type.

GENUS SAGITTA

The genus Sagitta as revised by Fowler (:06) includes twenty-one species. Their general horizontal and vertical distribution is shown in the accompanying table taken from Fowler's (:06)

	Neritic	Oceanic	EPIPLANKTON									MESOPLANKTON						
			Atlantic Ocean					Indo-australian Ocean		temp. N. Pacific Ocean	sub-arctic Southern Ocean	Atlantic Ocean					Indo-australian Ocean	
			arctic	sub-arctic	N. temperate	tropical	S. temperate	S. temperate	tropical			arctic	sub-arctic	N. temperate	tropical	S. temperate	S. temperate	tropical
ARCTICA	+	+	+	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·
BEDOTI	+	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·
BIPUNCTATA	+	+	+	+	+	+	+	+	+	+	·	·	·	+	+	·	·	·
DECIPIENS	·	+	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·
ELEGANS	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
ENFLATA	+	+	·	·	+	+	+	+	+	+	·	·	·	·	·	·	·	·
FEROX	+	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
FURCATA	+	+	·	·	+	?	·	·	·	·	·	·	·	+	?	·	·	·
HEXAPTERA	+	+	+	+	+	+	+	+	+	+	+	·	·	+	+	·	·	·
MACROCEPHALA	·	+	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	+
MINIMA	+	·	·	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·
NEGLECTA	+	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·
PLANCTONIS	+	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
PULCHRA	+	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
REGULARIS	+	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·
ROBUSTA	+	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
SERRATODENTATA	+	+	·	·	+	+	+	·	+	+	+	·	·	+	·	·	·	·
SIBOGAE	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
WHARTONI	·	+	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·
ZETESIOS	·	+	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	+
HAMATA	+	+	+	+	+	·	·	·	·	·	+	·	+	+	+	·	·	+
PACIFICA	+	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·
SUBTILIS	+	+	·	·	+	+	+	+	+	·	·	·	·	+	+	·	·	+
CEPHALOPTERA	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
DRACO	+	+	·	·	+	+	+	·	+	+	+	·	·	·	·	·	·	·

FIG. 1.—Geographic Distribution of Chætognatha, after Fowler (:06).

(Siboga) report. *S. bipunctata* is omitted by him from the Indo-Austral region in his text because of the uncertainty of its identification since it is quite similar to the young of several other species in the list. Of the twenty-one species, eleven, including *S. bipunc-*

tata, occur in the Atlantic, ten in the Indo-Austral, eight in Japanese waters, and two in the subantarctic, in the epiplankton. In the mesoplankton of the Atlantic eight species are found, and three in the Indo-Austral. In the larger geographical regions of the Atlantic we find coincidently in the epiplankton, in the Arctic, three species, in the subarctic five, in the north temperate, eight, in the tropical, five, in the south temperate, four; in the

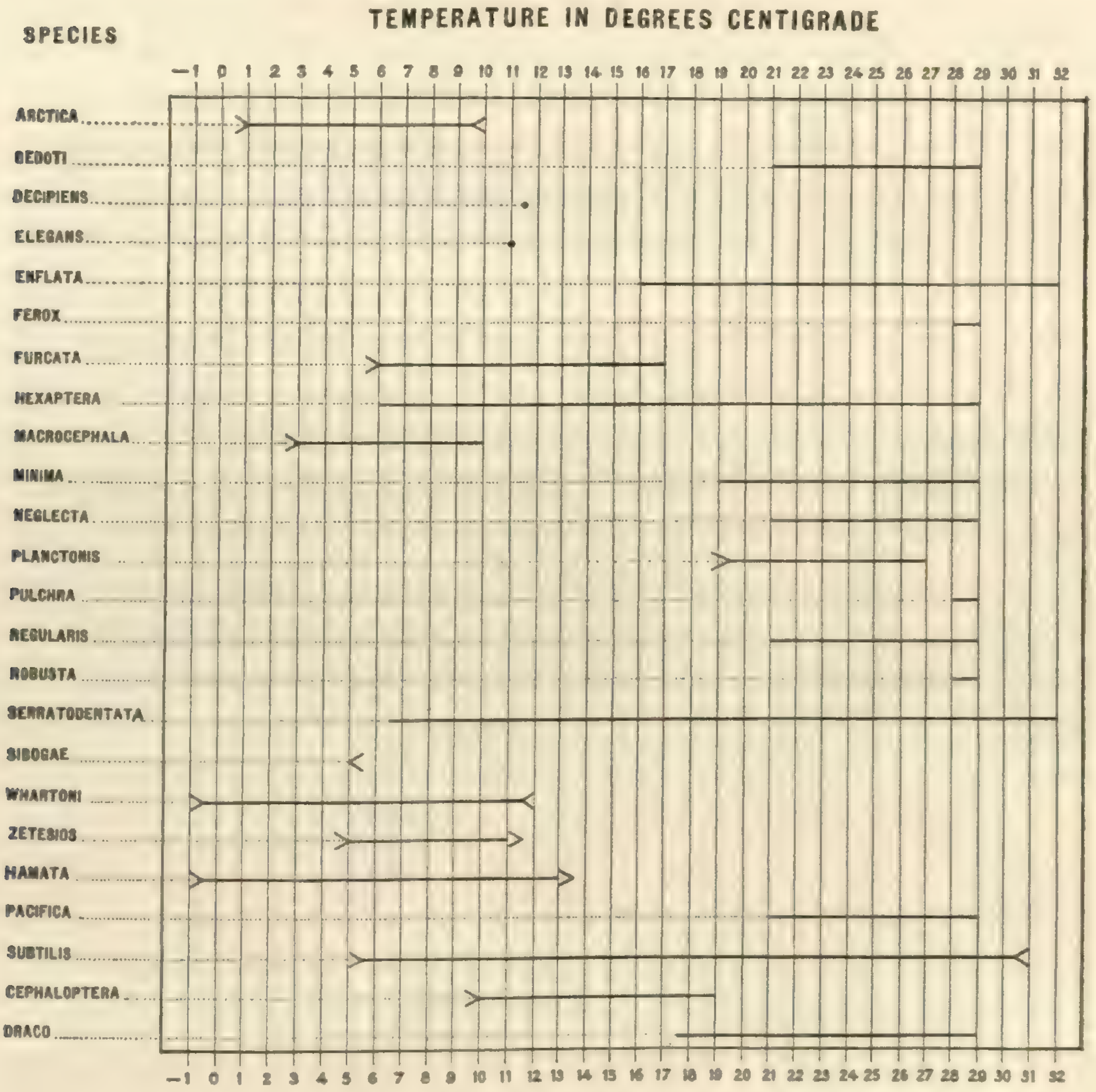


FIG. 2.— Distribution of Chætognatha with reference to temperature.

mesoplankton, two, eight and two species respectively in the subarctic, north temperate and tropical regions. In the Indo-Austral there are three species in the south temperate and ten in the tropical, with three in the mesoplankton of the latter.

The distribution of the species with reference to the temperatures at which they have been recorded is shown in the accompanying table from Fowler's (:06) report.

In the case of Sagitta the distribution is as follows:—

-1° to 4° — 3 species
5° to 10° — 7
11° to 15° — 6
16° to 20° — 6
21° to 25° — 8
26° to 32° — 11

This, in conjunction with the fact that some of the low temperature species belong to the mesoplankton of the tropics, indicates that the center of radiation of the genus has been in the tropics, or that specific differentiation has been relatively more rapid in that region than at the lower temperatures toward the poles.

These broader outlines of the distribution of the species of Sagitta are suggestive of a considerable degree of coincidence of distribution of species, it may be of closely related ones, and prompts to a closer analysis of their relationships and distribution.

The determination of degrees of relationship among species of a genus is a matter of inference from structural details for whose relative values we have no absolute standard. One's judgment is guided by the selection of characters on which classification is based, by experience in dealing with the specific analysis of the material, and subjectively, by the conception of species which one entertains. It is obvious that species differentiated by the slow accumulation of minute fluctuating variations would offer in their modified structures, some clue to the distance of their removal from the parent stock, or from each other. On the other hand the elementary species arising by mutation from *Œnothera lamarckiana* may be regarded as genetically equally related to each other or to the parent stock, but if we base our judgment of the degrees of the relationship which they exhibit solely on the structural characters which distinguish them, we would be forced to conclude that there was considerable disparity of relationship among them. The mutation theory admits a wider latitude in estimating the relationship of species than does the unmodified Darwinian point of view.

We have, however, in Sagitta only the result, and not the process of specific differentiation with which to deal, and are therefore

forced to depend solely upon structural resemblances for the determination of specific relationships.

The species of Sagitta are distinguished, among other less quantitatively expressed characters, by (1) size, (2) ratio of tail to total length, (3) number of jaws, (4) number of anterior and (5) posterior teeth. An analysis of Fowler's (:06) specific diagnoses reveals three groups of related species within which couplets of most closely related species may be noted.

The first of these, the *serratodentata* group, includes five species: *S. serratodentata*, a eurythermal cosmopolitan species with little tendency to sink to deeper waters in the tropics; *S. bedoti*, a neritic surface species from Indo-Austral waters; *S. ferox* and *S. robusta*, neritic and surface species from the Malay and Maldive Archipelagos; and *S. sibogæ*, taken only in hauls from deep water in the Malay Archipelago.

The following table of quantitative characters of the species taken from Fowler's records serves rather to indicate their close resemblance than to differentiate them. Other characters such as proportions, form of the eyes and teeth, assist in diagnosis.

Serratodentata Group.

Species	Length in μ	Tail in % of total length	Jaws	Anterior teeth	Posterior teeth
serratodentata	5–14	28–36	5–7	8–9	16–22
bedoti	13–20	21–28	6–7	8–10	17–29
sibogæ	9–20	21–33	5–7	7–10	16–22
ferox	10–20	29–36	5–6	6–10	9–14
robusta	10–14	25–33	5–7	6–9	10–15

The quantitative characters of the table in conjunction with others not included, suggest that the wide ranging *S. serratodentata* may be the ancestral stock of the couplets *bedoti – sibogæ* and *ferox – robusta*, or more nearly related to that stock than the couplets named.

The 'Siboga' lists indicate that these five species occur in the waters of the Malay Archipelago, but *S. sibogæ* only in collections from the deeper waters. The other four, however, are found together repeatedly in collections from the surface. In the 65 collections in which *Sagitta* occurs all four species appear in 27, three of them in 27, two in 9, and one in but 2, the average percent-

age of coincidence 80%. Of the 65 collections 55 were made at the surface. Four of the five species thus have a coincident distribution, including the mostly closely related couplet *ferox–robusta* and the very closely related *S. bedoti* and *S. serratodentata.* The *bedoti-sibogæ* couplet appear to have a contiguous distribution in the upper and lower levels, respectively, in this region.

A second group of species which show considerable resemblances to each other are *S. hexaptera*, an oceanic, stenohyaline, eurybathic, and eurythermal form; *S. enflata*, a warm water form of wide distribution in the epiplankton of warm-temperate and tropical seas; and *S. pulchra*, a neritic surface form from the Malay and Maldive Archipelagos.

The accompanying table indicates the relationships of the three species of the *hexaptera* group as suggested by the quantitative characters.

Hexaptera Group.

Species	Length in μ	Tail in % of total length	Jaws	Anterior teeth	Posterior teeth
hexaptera	15–70	20–25	6–8	3–4	2–7
pulchra	9–22	18–27	5–7	6–9	10–15
euflata	22–26	16–22	7–9	7–10	12–17

An examination of the 'Siboga' lists shows that the three species occur together in 24 catches, two in 26, and but a single one in 26, the percentage of coincident occurrence being 66%. The most closely related couplet in this group is *pulchra-enflata*, the former a neritic, the latter an oceanic species. These two occur together in the Maldives and also in the 'Siboga' collections, where *S. enflata* is one of the most abundant species. It is found in every one of the 34 collections in which *S. pulchra* appears. Of the 34 coincident occurrences 29 are in surface collections. These three related species have here a coincident distribution and *S. hexaptera* and *S. enflata* have a common distribution over a much wider area.

A third group of related species includes *S. bipunctata*, and two couplets of most closely related species, *furcata–planctonis* and *neglecta–regularis*. Published records indicate that the first named species is a cosmopolitan one of wide range. Difficulties attend its specific determination so that Fowler is of the opinion that it is possibly only an Atlantic neritic form not occurring in Indo-Pacific waters.

The members of the first couplet, *furcata–planctonis*, are Atlantic species, the former of wide distribution, 51° N. to 7° S., in the epiplankton of colder waters (17°) and the mesoplankton of the tropics. The latter occurs only in the epiplankton of the tropics. This couplet of most closely related species has a contiguous rather than a coincident distribution. The distribution of both, however, is overlapped by that of the very closely related *S. bipunctata*. The degrees of relationship as suggested by quantitative characters may be inferred from the accompanying table.

Bipunctata group.

Species	Length	Tail in % of total length	Jaws	Anterior teeth	Posterior teeth.
bipunctata	12–20	21–25	8–10	4–7	8–18
furcata	21–27	22–24	6–7	4–6	9–10
planctonis	17–23	23–26	7–9	6–8	9–10
neglecta	5–10	26–40	5–8	4–6	9–12
regularis	4.5–7	28–40	5–7	2–4	4–6

The members of the second couplet of most closely related species, *S. regularis* and *S. neglecta*, are both surface neritic forms of the Malay Archipelago and Japanese waters. *S. regularis* is neritic also about the Maldives and it may be that Doncaster (:03) overlooked the very similar *S. neglecta* in the collections from these waters. The distribution of these two most closely related species is thus widely overlapping, if not indeed coincident.

The distribution of pelagic organisms, as illustrated by the Chætognatha thus affords several probable instances of the isolation of the members of couplets of most closely related species by isotherms or isothermobaths. This isolation is similar in many of its aspects to that so often found between terrestrial species. It may well be that isolation has been an essential factor in the differentiation of the members of these couplets. Even more general, however, in the pelagic world and among the species of this same group is the phenomenon of the coincident occurrence of couplets, and of larger groups, of most closely related species. We have now no evidence of differential seasons, temperatures, or levels at which breeding might occur in these closely related species. Should these differentials ultimately prove to be absent.

we would be forced to conclude that isolation has had no part in the origin, differentiation, and continuance of these related species.

In *Dagitta bipunctata* Miss Stevens (:03) has described a method of close fertilization. As yet we have no light on the extent of its occurrence in other species where the presence of enlarged seminal vesicles and external male parts affords suggestive though not conclusive evidence of external and presumably of cross fertilization. Should all species of Chætognatha prove ultimately to have close fertilization we would have in this a most effective means of isolation.

The apparently wide-spread phenomenon of coincident distribution of related species among pelagic organisms appears to cast some doubt upon the universality of the operation of isolation in the evolution of species as originally maintained by Moritz Wagner ('68) and recently revived by President Jordan (:05).

The contrast here afforded also raises the question whether the two types of 'species' really belong fundamentally to the same category or not. Are those with contiguous distribution, and also many of the geographical species and subspecies of land vertebrates, of a standing exactly equivalent to that of those having a coincident distribution? Are, for example, *S. furcata* and *S. planctonis* merely the extremes of an environmental series beginning in the warm surface waters and ending in deep waters of lower temperature? In other words are they the result, in part at least, of the pressure of the environment? A statistical study of the distribution and variation of such a pelagic couplet and a comparison with a similar study of a couplet having a coincident distribution would be most instructive in indicating whether or not any distinction exists between 'isolation-environmental' species on the one hand and 'selection-mutation (?)' species on the other. Are intermediate forms equally absent in both types of couplets? Is variation similar in kind and in distribution among the individuals of the two types? Above all will the individuals of the isolated couplets maintain their specific integrity if their environments are transposed? And finally will the species with coincident distribution exhibit any greater specific stability under environmental changes than will those produced by the agency of isolation?

Investigators of pelagic organisms have been morphologists so

generally, rather than primarily systematists, that the bearing of the data of the geographical distribution of the organisms with which they have been dealing, upon the broader problems of evolution has been somewhat neglected. It is greatly to be hoped that the life of the sea, primitive, ancient, diversified as it is, may yet shed some light upon the problems which this brief paper can do little more than suggest.

ZOOLOGICAL LABORATORY
UNIVERSITY OF CALIFORNIA
Dec. 15, 1906

BIBLIOGRAPHY

AIDA, T.
'97. Chætognaths of Misaki Harbor. Annot. Zool. Jap., Vol. I, pp. 13–21. Tab. III.

DONCASTER, L.
:03. Chætognatha, with a note on the variation and distribution of the group. Fauna and Geog. of the Maldive and Laccadive Archipelago. Vol. I, pp. 209–218, pl. 13, text figures 39, 40.

FOWLER, G. H.
:05. Biscayan Plankton collected during a cruise of H. M. S. 'Research,' 1900, Part III.— The Chætognatha. Trans. Linn. Soc. London, Zool. Ser. 2, Vol. X, pp. 55–87, Pls. 4–7.
:06. The Chætognatha of the Siboga Expedition with a discussion of the synonymy and distribution of the group. Siboga Exped., Monogr. XXI, 85 pp., 3 Pls., 6 Charts.

JORDAN, D. S.
:05. The origin of species through isolation. Science, N. S. Vol. XXII, pp. 545–562.

STEINHAUS, O.
'96. Die Verbreitung der Chætognathen im sudatlantischen und indischen Ozean. Inaug. Diss., Kiel, 49 pp., 1 Taf., 2 Karten.

STENNS, N. M.
:03. On the oogenesis and spermatogenesis of Sagitta bipunctata. Zool. Jahrb. Abth. f. Anat., **18,** 227–241, Pl. 20–21.

STRODTMANN,
'92. Die Systematik der Chætognathen. Arch. f. Naturg., Jahrg. LVIII, pp. 333–377, Taf. 17–18.

WAGNER, MORITZ.
'68. Ueber die Darwinsche Theorie in Bezug auf die geographische Verbreitung der Organismen. Sitzber. d. bayer. Akad. d. Wiss. München, Bd. 1, pp. 359–395.

THE ATTACHED YOUNG OF THE CRAYFISH *CAMBARUS CLARKII* AND *CAMBARUS DIOGENES*

E. A. ANDREWS.

A REMARKABLE fact in the life history of the crayfish is that the young associate with the mother for many days after leaving the egg, being at first firmly fastened to her and later going back to her for protection until finally quite independent.

As pointed out in *The American Naturalist*, March, 1904, *Cambarus affinis* molts twice while fast to the mother and leaves her only in the third stage. Some facts as to the character of this incipient family life in an American Astacus from Oregon will be given in another communication. The object of the present note is to describe the association of parent and offspring in two more species of Cambarus and to compare this with what is found in *C. affinis* and in Astacus. The illustrations are all of *C. clarkii*.

The young of *C. clarkii* were obtained from eggs laid in confinement by adults shipped from New Orleans, November 18, 1904; some 18 out of 61 surviving the journey. Two of these active, prawn-like and brilliant red crayfish, one male and one female lived in a shallow sink of warmish water during the winter and by March 25, 1905, the single female had the abdominal basket full of many very small and very dark-colored eggs. These eggs were already in the stage H of Reichenbach but differed from that in having the abdomen larger. Each egg was about 1½ mm. in diameter and partook of the exceptionally vivid coloring of the adult, the large oil-like yolk drops being wine colored instead of yellow as in *Cambarus affinis*.

When received in November, three of the females examined had only minute yellow eggs in the ovaries and no sperm in the annuli, while the males had small testes but yet mature sperm in the vasa deferentia. It would thus appear that the season of conjugation may be late autumn or winter, and that of laying early spring, but this can be determined only by observations in the field.

By April 17 the eggs had become coated over with a dark deposit, but the embryo within was far advanced and easily escaped when pressure caused the egg case to spring open. With Zeiss 2. A. it was evident that the embryo was clothed in a loose cuticle, or cast off shell, which loosely invested the tips of the first and second antennæ, the chelæ, the walking-legs, the abdomen and thorax as well as the ends of the gills when torn out of the gill chamber.

These embryos were now essentially the same as when they hatched three days later. The eyes were almost sessile and with the pigment restricted to a narrow crescent and this pigment reflected yellow light but appeared black by transmitted light. The yolk was still a large dark mass of saddle-bag shape. The tips of the fourth and fifth legs were strangely bent back like hooks while the tips of the claws of the chelæ did not as yet seem to be recurved. All over the body the extremely dark crimson pigment cells again emphasized the agreement of embryo and parent in intensity of coloration.

But the detail of anatomy of the telson was the most important character for understanding the subsequent attachment of the young to the parent. The abdomen ended in a simple, flat, rounded telson that bore a row of simple spines along its posterior edge as seen with 2. D. in figure 3. The spines were fourteen or fifteen on each side symmetrically placed right and left, and a group of seven or eight of them on each side, near the median plane, seemed to push off the loose cuticle, which on the middle plane, was close to the body. The spines, or better, papillæ, were highly refractive and clear except that some showed granules and some vacuoles in their homogeneous contents. Some of them had small protrusions at the tips as if paste-like material had extruded from within.

The spines in the special group, right and left, converged, arched over, met and seemed grown together. On the animal's left the spines 7 and 11 were grown together at their tips while 8 and 10 seemed fused together at the tips into one continuous arch and the same was true of 9 and 12. With higher power, 4 mm. 4.45 comp. oc., tufts of fine threads, or fibrils were seen diverging from the tips of many spines to pass, posteriorly, often beyond the tips of other spines. Some of these threads passed out to the

loosened cuticle and seemed fastened to it. On the right of the specimen fine wavy lines suggested secreted films rather than fibrils.

As will be seen later these specialized spines are glandular structures that make the telson adhere firmly to the cast-off cuticle and thus make possible the "telson thread" of the hatching larva.

The small number of spines so grouped, together with the fact that the telson of earlier embryonic stages is incised on the middle of the posterior edge suggests that these 7 or 8 spines may be comparable to the 7 or 8 spines seen on each side of the incised telson of the lobster embryo (Fig. 72; Herrick; The American Lobster) before it molts at the time of hatching and is in a stage which Herrick compared to a protozoea, or other early larva. On this basis a very remote ancestral state has been retained to the extent that its spines have been applied to the new use of attaching the larva to its cast cuticle.

Before speaking of the hatching larvæ it must be recalled that all crayfish eggs are fastened to the pleopods of the mother by a hardening mass whose origin is somewhat in dispute. In *C. clarkii* the pleopods of the mother were so translucent that the transverse striation of the muscles was seen through the exoskeleton and with 2. D. the gland cells that are supposed to take part in fixing the eggs to the pleopods were seen as polygonal areas of secretion droplets separated by clear lines.

All over the bases of the pleopods these areas were massed together but the terminal part had them arranged in transverse bands that crossed the anterior face and extended into the sides but left the posterior face without glands. On the bands anteriorly were small tubercles each with a number of tubes passing from the glands to the surface and near these were some short, sharp setæ which occurred again at the tips of the pleopods.

While it is possible that these sharp setæ act in pricking the eggs and liberating an adhesive material as claimed by Williamson for crab's eggs, and that the glands of the pleopods have nothing to do with fastening the eggs, yet this seems very improbable, as the eggs are fastened to a large mass of material similar to the egg case and stalk and which binds all the long plumose setæ together and is most probably the product of the pleopod glands.

The small first pleopods also had glands and setæ like the others but were more colored with large, arborescent, red cells.

When fastened to the mother each egg was in a remarkably elastic case which had a rough, dirty outside layer and a clear inner layer containing the same microscopic droplets seen in *C. affinis* and similar to the droplets coming from the pleopod glands. Each case was continued on one side as a long stalk that in turn was continuous with the hardened secretion binding together the plumose setæ along the edges of the pleopods. The stalk was hollow though flat and wide and was a continuation of the dirty outer layer of the egg case, separating from the inner layer on one side to form a large hollow bell or tent.

Between the egg and the egg case was a variable amount of coagulum showing fibrils in it.

By April 17th some of the larvæ had hatched while others were not yet out of the egg cases. The young, figure 1, had the usual embryonic look of crayfish at hatching; a huge swelling of the head region owning to the presence of much yolk there; a weak development of the locomotor part of the head-thorax so that the five pairs of weak legs all arose posterior to the middle of the head-thorax; a weak, down-bent abdomen of little use in locomotion; eyes almost sessile and of little size or perfection. These larvæ were transparent and showed the heart beating rapidly and the scaphognathites rapidly baling the water out of the gill chambers. The dark area in figure 7 represents the dark red yolk mass; and the scattered dots, the aborescent pigment cells that were thickly scattered over the head-thorax and abdomen with but few upon the third maxilliped, base of antenna, three basal segments of the antennule and some few segments of the periopods.

Normally the larvæ remained upon the mother and did not move about, and when pulled off and put on the bottom of the dish they could not stand up but could progress by lying upon the side and flapping the abdomen.

At hatching, figure 1, the young were so weak they would have dropped to the bottom but for the "telson-thread" which is the cast off cuticle pulled out into a thread or band and fastened at one end to the telson of the larva by the special telson spines described above and at the other end to the inside of the egg case. As the egg case still remains fast by its stalk to the mother the larva is hung suspended from the mother till able to use its claws

and obtain a hold by them to the egg stalk or to parts of the material covering the plumes of the pleopods.

In hatching the larva escapes not only from the egg case but from its loose cuticle and this cuticle, where it covers the abdomen, is pulled inside out, but leaves the telson spines fast as before to the inside of the cuticle over the tip of the telson. The cuticle is so strong that larvæ may be picked up by the telson thread and their weight does not break it even when hanging in the air.

The attachment of the cast cuticle to the inside of the egg case seems to be an indirect one; apparently the larval cast cuticle is in some way fast to the egg membrane and that in turn adherent to the inner of the two layers that makes the egg case, but this was not definitely seen. In many eggs the embryo when young lies upon the side of the egg near the stalk and we suspect some relation between the region of fertilization and of stalk formation. Later, when the embryo hatches, it goes out back foremost through a crack in the case opposite to the stalk. In the old embryos the tip of the telson is carried forward to near the eyes and not far from the stalk of the egg case and in that same region of the egg is found the connection of egg case to embryonic cuticle. Possibly there may be some common factor, as gravitation, that determines at fertilization the position of the embryo, the place for formation of the egg stalk and the connection of egg case and larval cuticle.

The part played by the special telson spines in holding the larva fast to the telson thread is shown in figures 2 and 4, which show how the wrinkled telson thread is connected to fibrillar material, fastened to and interlocked with the long, curved and arched spines. In passing from the condition shown in figure 3 to that in figure 4 the cuticle over the abdomen has been pulled off and turned inside out and is now free from the larva except where held by the material furnished by the glandular spines.

When the young get hold of the mother pleopods with their claws they soon break the telson thread, but a short end of it long remains fast to the telson and the main mass still recognizable is fastened to the egg case.

In this first larval stage these young crayfish were about $4\frac{1}{2}$ mm. long from tip of telson to a point between the eyes where the rostrum turned down close against the head and was concealed between the eyes. The antennæ were $1\frac{1}{2}$ mm. long.

The accompanying camera sketches from specimens hardened in Worcester's liquid show the generally imperfect state of the appendages of the first larva, which lived for a few days an inert embryo-like existence fastened to the mother and not eating but only rapidly aerating and circulating its blood as the yolk was being transformed. The first antenna, figure 8, has only four segments in its exopodite and in its endopodite and agrees with most of the other appendages in being devoid of setæ. This bareness of the appendages of the first larval stage was first pointed out in the English Astacus by Huxley and seems common to all crayfish larvæ in their first stage. In place of setæ there are but a few spinules at the tips of the first antenna and on the basal segment there is a small ear-pit; but as yet the entire appendage would seem of no use as a sense organ.

The second antenna, figure 9, has only 24 segments in the slender part of its filament, beyond the three large broad segments, and the exopodite scale bears a blunt process and a row of few, sharp spines. The tubercle upon which the nephridial canal opens is, as in all young crayfish, proportionally very large.

The mandible, figure 10, has a smooth edge with no teeth and is probably not used. The first maxilla also, figure 11, is very simple and probably of no use.

The second maxilla, on the other hand, figure 12, bears the large scaphognathite which is very active in removing water from the gill chamber. The setæ along the edges of the scaphognathite, though represented in the figure as smooth, were in reality, under 2. D., set with five side branches so that in this only actively moving appendage the setæ are present as plumes that would seem to be of use in striking against the water and in making the appendage fit more closely into the passage leading out of the gill chamber.

The three maxillipeds, figures 13, 14, 15, are strangely lacking in setæ except upon exopodite of the first where there is a row of sparsely plumose setæ. The gills begin as a large podobranch and a slender anterior arthrobranch on the second, figure 14, and on the third, figure 15, there are two arthrobranchs. The projecting lobe at the base of the epipodite, or lamina bearing the filaments of the podobranch, is conspicuously large in all larval crayfish and here bears a few, acicular setæ. Probably these

lobes and setæ aid respiration in making the inlet water more free from dirt.

The chelæ, figure 16, are long and strong but as yet not specialized as cutting organs. The tips of the claws are recurved as Huxley first found them to be in the English Astacus so that once shut upon a penetrable mass they could scarcely be loosened by the larva, figure 17. By means of these locking tips the young become fastened to the egg stalks and to the hardened secretion on the mother's pleopod setæ so that they probably remain fixed in one spot all the time they live in the first stage. The simple, acicular setæ seen along the edge of the claw, figure 17, may possibly aid in tactual reflexes to enable the larva to shut its claw on suitable substances.

The next two pairs of legs are very like the chelæ, but more slender, short and weak.

The fourth leg, figure 18, with no claw, has its arthrobranchs much reduced, the anterior having but slight protuberances to represent lateral filaments and the posterior being quite smooth.

The fifth leg has no gills at all associated with it; the pleurobranch of Astacus being absent not only in the adult Cambarus but in the earliest larva here as well as in *C. affinis* and, as long ago determined by Faxon, in *C. rusticus*. The branchial formula is thus the same in the larvæ as in the adults.

On the abdomen the appendages have the incompleteness of all crayfish larvæ. The first pair are not begun and the sixth pair are forming under the exoskeleton within the base of the telson. The other four pairs are very small and apparently quite useless structures each projecting towards its fellow crosswise under the abdomen and with the endopodite more anterior and the exopodite more posterior. As seen in figure 19, the endopodite is somewhat the larger and both endopodite and exopodite are very simple and show but slight suggestions of spines at their tips.

The telson, figure 2, is a simple, elongated, flat plate showing within its clear substance radiating lines ending at the marginal spines and also the outlines of the long exopodites of the sixth pleopods lying along on each side of the rectum and anus. On the ventral side, figure 1, the base of the telson is quite protuberant over the part of the enclosed pleopod that will be the exopodite.

In larvæ that have been in the first stage a few days and are about ready to molt it is obvious that the radiating lines in the posterior part of the telson are the glands secreting the setæ which will replace the marginal spines at the next molt. In a prepared section of the posterior part of the telson of such a larva, figure 5, the old cuticle is separated from the epidermis by a space across which the tips of the forming setæ pass toward the hollow bases of the old spines. Each old spine has a new seta beneath it but as there are also other setæ the second larvæ will have more setæ than the first had spines; the long plumes, however, figure 7, are slightly fewer in the second larvæ than the spines in the first.

Each developing plumose seta seems a flat plate ending in a fine central thread and with its edges frayed out in short fine threads. The base of each is deep within the epidermal ingrowth that forms the secreting gland. Each gland seems a row or rod of cells, indicated by large nuclei in a common protoplasm in which no cell walls were seen. The longitudinally striated base of the plumose seta forms the axis of the rod of cells. The space between the radiating glands was in part occupied by blood, staining, like the setæ, yellow, while the nuclei were red in borax carmine and orange G.

Similar, but less developed rods of cells were also seen in sections of the internal buds of the sixth pleopods where they were forming plumose setæ that projected into a bag surrounding the pleopod.

By April 24th, when some of the larvæ had begun to molt, it was evident that something was abnormal, as some larvæ in both the first and the second stages fell away from the mother and died. The mother also died, April 28th. The hatching was prolonged more than is probably normal so that many first and second stage larvæ were found side by side for a few days. Some of the young in the second stage remained with the mother for a few days but made excursions away from her and again returned as was the habit for the second stage in *Astacus leniusculus*, but it is not certain that this was normal in *C. clarkii*. While upon the mother these young held firmly with their chelæ, but they let go when the dead female was lifted out of the water. When upon the bottom of a dish they were able to stand up and walk feebly, and after a day, they swam backwards on their sides by flapping

the abdomen. They tended to climb over one another and one held so fast to a dead fellow that it could be shaken loose only with difficulty. They also climbed up on to the dead female and on to a piece of Canton flannel where they held fast by their chelæ for a time and then got down and swam actively if disturbed by a pipette.

Though the larva in the second stage may thus go away from the mother it doubtless returns even into the third stage as Faxon records finding upon the abdomen of museum specimens larvæ with characters evidently of the third stage.

The second stage young, figure 6, were still so translucent that in the abdomen the digestive tract and the ventral ganglia could be plainly seen.

In *C. affinis* it was noticed that the young, in passing from the second to the third stage, was suspended from its cast cuticle by an anal thread which bound its anus to that of the cast off cuticle and as the claws of that cuticle still held fast to the mother the young was prevented from dropping away from the mother till able to take hold again with its new claws. In *C. clarkii* the same arrangement may prevail though it was noticed only in two larvæ that died just after molting. In these there was a long thread that issued from the anus and, passing down through the hollow cast off cuticle of the abdomen, was fastened at the bottom of it to the flat telson. By the strain of the anal thread the cast off abdominal cuticle had been telescoped; the old telson being dragged up against the collapsing rings of the cast cuticle. As in *C. affinis* this anal thread was only the cuticular lining of the intestine not cast off entirely at the same time with the external cuticle and thus serviceable in binding the larva to its old shell. If this tardiness in casting the lining of the intestine is normal in *C. clarkii* it would seem a useful means of holding the young to the mother when soft and helpless at molting time, provided the young molts while upon the mother, which is probably the case even if it has some freedom of motion in the second stage.

In contrasting the second stage, figure 6, with the first, figure 1, we find an increase in size, the body being now 5½ mm. long with antennæ 3 mm. long, and some advance in the proportions of the body and in the perfection of the limbs. While the head-thorax

still contains much yolk it is less swollen and more elongated while the abdomen is relatively larger and it is more useful as its telson bears a fringe of setæ.

The limbs are changed but little, yet they now bear some setæ though these are too small to show under low magnifications, figure 6. The rostrum is still triangular, but sharp, and though it is still bent down between the eyes it can be seen from a dorsal view and also from a side view, figure 6, where its base is visible near the eyes which are now decidedly stalked.

The first antenna had six segments in its exopodite and in its endopodite and the former bore five sense setæ, three on the terminal and two on the fifth segment. The ear was a wide open cavity with three or four finely barbed setæ along its external border.

The second antenna now had a long spine and a row of 19 or 20 plumose setæ on its scale and its filament contained 34 segments some of which seemed to be dividing.

The mandible edge was now no longer smooth but had six or seven teeth on its free edge and three above the palpus.

The spines at the tips of the chelæ, figure 20, stood at about right angles and were but slightly recurved. Along each edge of the claws was a row of peculiar spines having a thick edge and a narrow blade, figure 20, which tended to be cracked or striated across its length. These cutting or rasping spines are a specialization not found in the first stage when the claws are used only as hold-fasts.

On the abdomen no new appendages were found but the four pleopods present were now well provided with plumose setæ. The telson of the second stage, figure 7, compared with the first stage, figure 2, shows a great increase in size and the addition of a row of barbed setæ in place of the simple marginal spines. The sides of the telson protrude so much where the enclosed sixth pleopods have enlarged that its margin is somewhat three lobed; all the setæ are upon the middle or posterior lobe, and are symmetrically placed right and left. In the middle line there are no setæ; and right and left they begin short and suddenly reach the greatest length and then, as seen in figure 7, are long enough to make an efficient increase in the length and area of the telson as an organ for striking against the water in swimming.

In the figure the dotted lines represent the enclosed pleopods and in them the radiating setæ glands in which are forming the plumes to be expanded at the next molt. Studied in life with Zeiss 2. D. these glands were long tubes from each of which projected a plume, the tip of which turned to one side in the space between the edge of the pleopod and the enveloping sac. In the same way the posterior end of the telson showed long tubular glands forming a set of plumose setæ to replace those already present. The tip of each new plume projected slightly from its gland into the hollow base of the existing plume, which would be cast off with the cuticle of which it is a part, at the next molting. All these setæ seen in formation in long tubes are richly barbed plumes that later come into use when suddenly exposed to the water at the next molt.

Only some five or six of these specimens of *C. clarkii* survived to change into a third stage, April 29 to May 1st, but these agreed with all known crayfish of the third stage in having a complete tail-fan, with both telson and widely expanded sixth pleopods together forming a very large area for resistance to the water and set all along the combined edges with the above long plumose setæ.

Though these few individuals seemed weak they both walked and swam easily. The color had now become a darker flesh-color from the crowding of red pigment cells, but the area about the stomach was lighter and on each side of the stomach there was a small, narrow, dark band representing the yolk.

As above stated it is probable that in nature the larvæ in the third stage remain with the mother for a time, and then gradually become entirely independent.

While the conditions seem to have been so unfavorable for *C. clarkii* that the young were weak and probably somewhat abnormal in their actions this was not the case with the young of another crayfish, *C. diogenes* Girard as kindly determined by Walter Faxon. April 8, 1906, ten females with eggs in late stages, three females without eggs and twenty-two males were obtained from Talbot Co., Maryland, by a collector who stated that they usually breed in May and are caught walking about in ditches.

The eggs were nearly black, or upon a few females dark brown, and of great size, being $2\frac{1}{2}$ to 3 mm. in diameter, while in *C. affinis* they are $1\frac{3}{4}$ to 2 mm. and in *C. clarkii* only $1\frac{1}{2}$ mm.

The young were hatching upon six of these females May 22nd and just before this an examination of the embryos showed a delicate loose cuticle over each tip of the chela, over the abdomen, and over the body, and an egg opened in strong sugar solution, and then put into water showed a cuticle swelling up all over the antennæ, the chelæ and the abdomen. But when carefully dissected it seemed that this cuticle was not a case over each appendage but rather that it was a large bag over the thorax, a side pouch over the abdomen, a large side pouch over all the pereiopods and a side pouch over all the gills. Probably, however, there are two thin membranes, an outer vitelline membrane of irregular form when stretched over the protuberant regions of the animal and an inner, real cast-off cuticle, that goes over each appendage; for some dissections showed the embryo inside a delicate spherical bag fastened to the inside of the egg case, and observations upon the hatching larvæ seemed to show them drawing out the limbs from separate envelopes.

At the end of the telson there were groups of spines fastened to the cuticle by refractive fibrillar coagulum. On each side a group of six spines arched over and connected very much as in *C. clarkii*, figure 3, and here the cuticle was thrust off further, while on the middle line it was close to the telson.

In one individual the actual hatching lasted forty-five minutes; the egg case cracked open opposite to the stalk and the embryo slowly "oozed" out back forward. During this process some movements of the legs were seen as well as a rhythmic pulsation of the lateral lobe of the liver lying close to the yolk mass on each side of the body, and swaying movements of the yolk mass. This tube was filled with yellow liquid for ten or twelve seconds and then grew narrow and white for about two seconds and again filled. It seemed as if the tube were contractile itself, but the yellow liquid may have been forced into it and so have caused it to distend. In either case the rhythmic filling would seem useful in aiding in digestion of the yolk, which was the only available food so far. Should it prove that the adult liver also rhythmically fills and empties it would be an interesting addition to the anatomical and physiological evidence advanced by H. Jordan (Pflüger's Archiv, 1904,) to show that the 'liver' is the chief organ for absorption as well as secretion.

As soon as out of the egg case the larva began to kick its legs and in a few minutes the scaphognathite slowly moved, stopped and began again, finally establishing a rapid rhythm. On adding carmine, the currents made by the scaphognathite were visible and its movement seemed comparable to a scooping motion of a hollowed hand, the fingers downward, thus forcing the water through the dorsal part of the respiratory passage as the fingers closed the lower part and then rising up to close the upper part and prevent a back set of water into the passage way.

Once out of the egg case the larva was still fastened to it by a telson thread consisting of a short string from the telson spines to a large crumpled mass that seemed a cast off cuticle and lay just within the gaping egg case and was fastened to it, inside, by the intervention of an expanded membrane which may possibly have been the old vitelline membrane. This membrane was bound to the inside of the egg case by a few short fibrils over a round area smaller than the base of the egg stalk and often near it. Thus suspended the larva moved its legs weakly and now and then shut its claws and violently flapped its abdomen without breaking loose from the telson thread. Soon the larvæ became fast by their claws to the egg stalks or to the material on the plumose setæ of the mother's pleopods.

In this first stage the larvæ remained cowered down close to the pleopods and were so firmly fastened to the mother by their claws that they did not break loose when the pleopod was thrown into Worcester's liquid, though they jerked their legs and powerfully and violently flapped their abdomens. Those left locked to the pleopods of the mother lived three to four days and then molted into a second stage, May 26.

They were very large, 5 to 6 mm. long when stretched out and $4\frac{1}{2}$ mm. as they lay with the weak abdomen carried forward under the thorax and were very attractive objects because of the swaying of the dark red and golden yolk mass, the contractions and change in color of the lobes of the liver spread like the fingers of a hand deep in over the back, and of the fiery, ruby-red, neuron-like, branching pigment cells spangled over a body so translucent as to show the white blood corpuscles hurried along the vessels over the red yolk, along the sinus at the edge of the carapace and out and in through the legs and antennæ like shuttles.

Camera lucida sketches of the first larva of *C. diogenes* showed it larger than even the second stage of *C. clarkii* but in simplicity and proportions essentially like the first stage. As usual in hatching crayfish the appendages were almost all bare of setæ; the eyes were nearly sessile; the rostrum a small triangle close to the body and between the eyes. The yolk far forward in the head-thorax distended that region and left the region for the gills and pereiopods of less extent.

In the first antennæ there were four segments in the larger, club-like exopodite and also in the slender, smaller endopodite and there were no sensory setæ.

The second antennæ were carried curved backward and downward but not close against the thorax as in *C. affinis* and each had only spines upon its scale and 35 segments on the slender part of the filament.

The mandible had no teeth but its edge was very slightly waved where the epidermal cells seemed about to secrete slight thickenings.

The scaphognathite used as a baling organ also was exceptional amongst the appendages in bearing plumose setæ which formed a row along the edge and were longer and more easily seen than in *C. clarkii*.

The gills were larger and with more side filaments than in *C. clarkii* but were suddenly reduced upon the fourth pereiopod so that the anterior arthrobranch had but a few filaments and the posterior none. On the last thoracic somite there were no gills, as is the case in all the young of Cambarus thus far studied.

The four pairs of pleopods had the endopodites slightly longer than the exopodites and the entire appendage was very much longer than in *C. clarkii* and with evident spines on both tips.

The telson with its enclosed pleopods was very much like that of *C. clarkii* and bore on its posterior edge the same kind of spines, about 14 on each side, six of which were specialized gland ducts arched over and joined together and bound to the telson string very much as in *C. clarkii*, figure 4. Inside the telson there were again the radiating glands making the plumose setæ of the second stage and a day before molting, the tips of the plumose setæ extended from their glands so far along, posteriorly, between the

epidermis and the loosened cuticle as to pass by several spines. Each new seta had its lateral barbs closely appressed against its axis. Moreover the new cuticle extended inward to line part of the seta gland so that in macerated specimens these cuticularized tubes ending abruptly, strongly recalled the like tubes that go in along the setæ of the earth worm. Probably at molting these sleeves become everted and so allow the sudden extension of the setæ to a length equal to the length of those tubes added to the length of setæ already lying between the old and new cuticles.

Molted into a second stage the young *C. diogenes* were 8½ mm. long, 1½ wide and 2 deep and had antennæ 5 mm. long. Until the next molt — some five days, May 26th to 31st,— they remained upon the mother's pleopods, but were not so firmly fixed as before as they fell off when put into Worcester's liquid.

While in most respects the larva was essentially like the second larva of *C. clarkii* a number of differences were noted.

The rostrum was less bent down than in *C. clarkii* and was long and pointed and visible from the side as its tip extended out beyond the eyes; its sides moreover were not straight as in *C. affinis* but arched so that something of the adult character was already expressed.

The first antenna was yet concave on the upper side of its base to fit against the eye and had in it a large open ear pit bordered externally by a few small spines and one very imperfect plumose seta. Beneath these spines the plumose setæ of the third stage were seen in formation. The exopodite bore seven sense setæ, three on the sixth and two on the fifth and on the fourth segments. The exopodites and endopodites were each divided into six segments.

The second antenna had some 13 to 15 plumose setæ on its scale and 38–42 segments on its filament.

The tips of the chelæ were still slightly recurved but as above noted the larvæ did not seem very firmly fastened by them.

Though the telson was larger than in *C. clarkii* its fringe of sparsely plumose setæ were noticeably shorter. There were about twenty on each side. In the base of the telson the large sixth pleopods showed a long exopodite, with a transverse joint, suggesting an index finger lying along the side of the telson while the endopodite was bent crosswise like a thumb.

A dissection of one of these second larvæ revealed a mass of membranous material and both simple and plumose setæ in the intestine suggesting that these larvæ may eat the egg cases and setæ from the mother's pleopods.

The creature was still translucent enough to show the ventral ganglia through the exoskeleton of the abdomen and was dotted over with pigment cells of stellate form, which when expanded were light red and when contracted very dark, while deeper in were diffuse and indefinite blue cells. In the antennæ and legs as well as in the antennal artery the corpuscles were going outward rapidly and returning somewhat more slowly in wider vessels.

Two days before molting into the third stage the new inner cuticle was already formed and the new setæ projected into the bases of the old. The yolk had become reduced to a small dark remnant on either side and even to the naked eye the gastroliths were conspicuous as two pink-white opaque areas, one on each side of the stomach enveloped in a clear glassy coat.

The third stage began by June 1st and had the adult character of a tail-fan made of the telson and the fully expanded sixth pleopods all fringed with perfect plumose setæ. These larvæ were $10\frac{1}{2}$ to 11 mm. long, 3 wide and $2\frac{1}{2}$ deep and expanded the tail-fan about 4 mm. while the antennæ were 6 mm. long.

These third stage larvæ when recently molted were still somewhat translucent and of a faint pink color with red-tipped claws and though the stomach was plainly visible the gastroliths were lacking on the outside. But within the actively moving stomach was a brownish liquid containing white particles or in some cases whole gastroliths moved about actively. In some cases the intestine contained colored material in its anterior part.

The specific gravity of the larvæ had so changed that they now floated in Worcester's liquid though the first and second stages sank; they were also less resistant to this fluid and died more quickly than when younger.

When the larvæ had changed into the third stage it was noted that the six mothers no longer had egg cases and cast cuticles upon their pleopods and as their fæces contained parts of plumose setæ of adult size it may be that they aided in cleaning off their pleopods though there is some evidence that the second larvæ may eat off

that material and Soubeiran stated that the young of an Astacus ate the egg cases and larval skins.

The third stage larvæ stayed near the mother some ten days or more, often, when disturbed, climbing on one another and crowding under and upon the mother, but after that they were quite independent and seemed to have no association with the mother though kept in the same small aquarium.

Walking and swimming the young sought food over the bottom of the aquarium and in a day cleaned off all the brown deposit from a spray of Myriophyllum and when another piece was given them ravenously set about tearing off and eating the bacterial slime and algal growths. When given Chara they seized an internode with their mouth parts and pushed it with their feet somewhat as a dog gnaws a bone, but when pieces of internode were cut off for them they seized them by one end and walked about sucking the contents out. Such a larva holding its head high and supporting a stick longer than its body, held by its mouth parts straight out in front of it, ludicrously suggested the enjoyment of a huge stick of candy. Animal food in the shape of a dead comrade was eagerly seized and pulled to pieces and a small earthworm was eaten up in a few hours.

Living thus, at a temperature of 85° F., the young were very active and darted away from the shadow of an object outside the water. After two weeks some molted without much change of size but by July 3rd some were 13 to 15 mm. long and the only survivor, July 15th, 18 or 19 mm. long.

From the above account it appears that the young of *Cambarus clarkii* and *Cambarus diogenes* associate with the parent in the first and second stages and in part of the third and this sort of family life is aided both by special recurved tips on the chelæ and by a peculiar telson thread; and as this is true also in *C. affinis* as well as in an Astacus of France and one in Oregon it is probably a general fact for all species of these two genera. Moreover all these crayfish show in the young structural characters and habits that make them unfit for free life like that of their marine relatives, the lobsters, and better fit them for a life of protected association with the mother with whom they live as in a kind of elementary family.

In this departure from ancestral conditions *C. affinis* has gone farther than Astacus in the following respects. In the first stage and in the second stage the telson is more reduced and both pairs of antennæ are more simple and to some extent this is also true in the other species of Cambarus here described. Thus in the first stage, Astacus has 50 to 66 spines along both the posterior and lateral edges of the telson while the three species of Cambarus have spines only upon the posterior edge and they are less than 30. Astacus also has in the first stage five segments in endopodite and exopodite of the first antenna and 50 in the filament of the second antenna while the three species of Cambarus have but four in the first case and 25 to 35 in the last.

In the first larval stage the three species of Cambarus thus agree amongst themselves and depart from Astacus in the direction of simplicity which is presumed to be a secondary reduction in connection with protected life upon the mother.

In the second larval stage *C. affinis* alone has spines merely and no plumose setæ upon its telson and is thus most remote from fitness for the active life of its ancestors. In the second stage Astacus is most like a free form in having its telson fringed with much more perfect and numerous plumose setæ than are found in *C. clarkii* or *C. diogenes*. In Astacus also the first antenna has its ear-pit well overarched by a row of plumose setæ but in *C. clarkii* there are only 3 or 4 plumes, in *C. diogenes* but one plume and in *C. affinis* only minute spines and no plumes. In Astacus the second antenna has 54 segments, in *C. diogenes* about 40, in *C. clarkii* 34 and in *C. affinis* 39. In *C. affinis* alone is there a retention of simple spines such as occur in the first larval stage, so that the scale of the second antenna here still bears no plumes.

Thus in the second stage *C. affinis* is most removed from Astacus but *C. diogenes* and *C. clarkii* depart less from the ancestral Astacus-like form.

Likewise in habit the three species of Cambarus agree in remaining attached to the parent during the second stage but in Astacus, however, as far as known, the larvæ become free in the second stage.

Apparently also Cambarus is more fitted to family life than is Astacus by having the anal thread at the time of passing from the first into the second stage.

From consideration of the larval life we come to the same general conclusion as that generally drawn from study of adult anatomy and geographical distribution, namely that Cambarus is a more highly evolved form than Astacus and that *C. affinis* is one of the higher, more specialized forms of the genus.

As to the relative position of *C. clarkii* and *C. diogenes* there is, however, doubt and discrepency. The adult characters seem to leave no doubt that *C. clarkii* is much the more primitive, less specialized and more like Astacus of the two. But in the adjustment of the larva to family life *C. diogenes* would seem to have progressed less far than *C. clarkii*, at least in the first stage *C. diogenes* has more segments in its second antenna and in the second stage more sense setæ in the first antenna as well as more segments in the second antenna. On the other hand *C. clarkii* would be more primitive in having more setæ over the ear-pit and if in nature the young actually get loose from the mother in the second stage they would be more like Astacus.

Yet in future study of crayfish it would seem that regard should be paid to the first three larval stages as aids in determining the relative positions of the species and their probable derivation from ancestral forms.

From a thorough study of larvæ of many species and from experiments in cross breeding some idea might be got as to the nature of the causes that seem to be leading some of the more evolved crayfishes to develop further that association of parent and offspring which forms in the crayfish a simple stage in family life.

December 20th, 1906

EXPLANATION OF PLATES.

All the figures were drawn with camera lucida and the Zeiss lenses indicated and were reduced to one third in diameter. They represent the first and second stages of *Cambarus clarkii*. Figures 1, 3, 6, 17 are from living and the rest from preserved specimens, fixed in Worcester's liquid.

FIG. 1. Larva just hatched from egg case with which it is connected by the telson-thread: 2.90 mm. a a.

FIG. 2. Dorsal face of telson of first larva with attachment of telson thread and internal pleopods, etc. 2. A.

FIG. 3. Dorsal face of end of telson teased out from egg about to hatch, showing investing cuticle over the glandular marginal spines. 2. D.

FIG. 4. Enlargement of part of such a view as Fig. 2, showing attachment of telson-thread to certain marginal spines. 2. D.

FIG. 5. Composite of surface views and sections of part of margin of telson of first stage. 6.4 mm.

FIG. 6. Right side of living larva in second stage. 2.90 mm. a a.

FIG. 7. Dorsal face of telson of second stage. 2. A.

FIG. 8. Dorsal face of left antennule of first stage. 2. A.

FIG. 9. Ventral face of left antenna of first stage. 2. A.

FIG. 10. Outer face of left mandible of first stage. 2. A.

FIG. 11. Outer face of left first maxilla of first stage. 2. A.

FIG. 12. Outer face of left second maxilla of first stage. 2. A.

FIG. 13. Outer face of left first maxilliped of first stage. 2. A.

FIG. 14. Outer face of left second maxilliped of first stage. 2. A.

FIG. 15 Outer face of left third maxilliped of first stage. 2. A.

FIG. 16. Posterior face of left chela of first stage. 2. A.

FIG. 17. Dorsal view of tip of chela of first stage alive. 2. D.

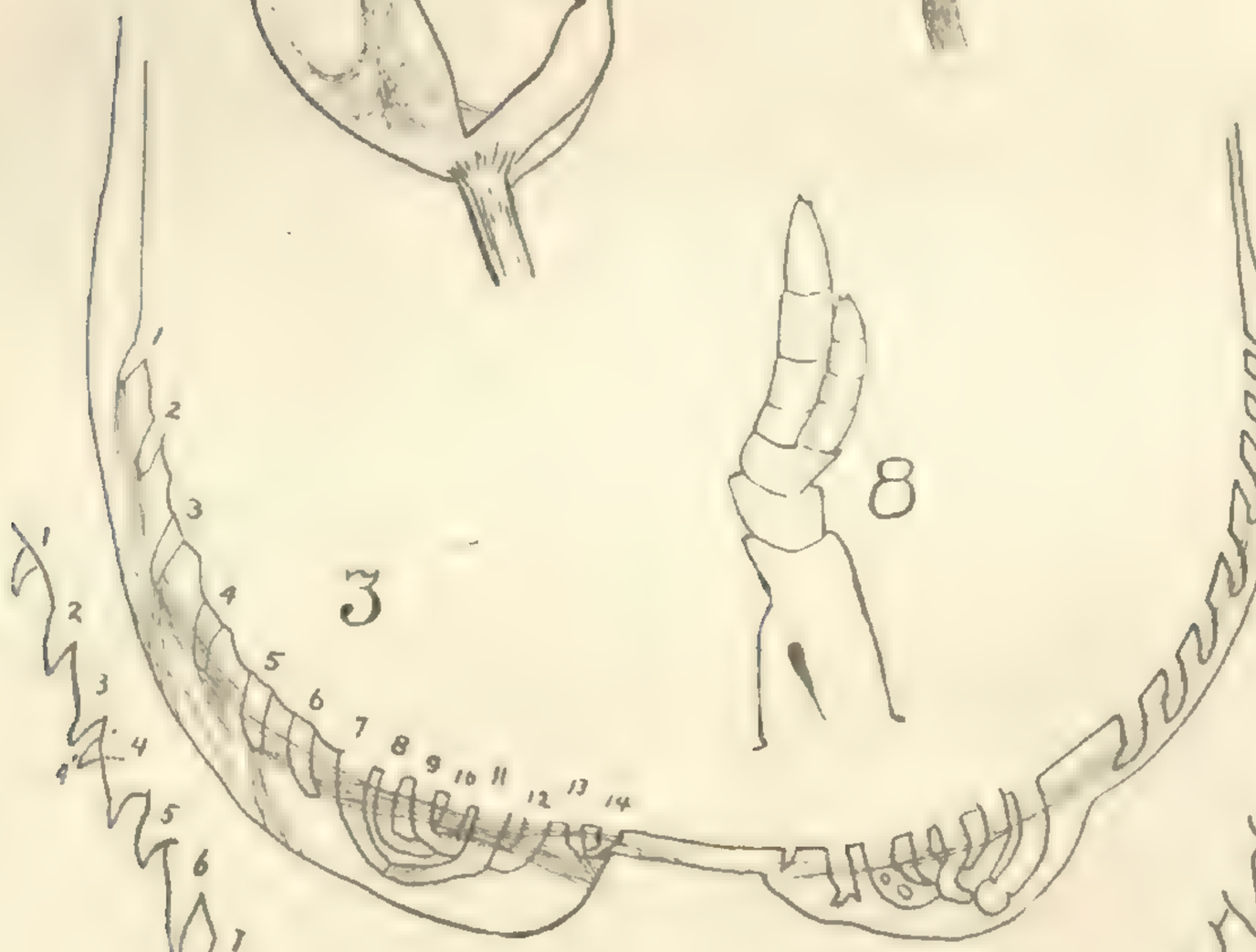
FIG. 18. Posterior face of left fourth pereiopod of first stage. 2. A.

FIG. 19. Anterior face of a left pleopod of first stage. 2. A.

FIG. 20. Tips of chela of second stage. 2. D.

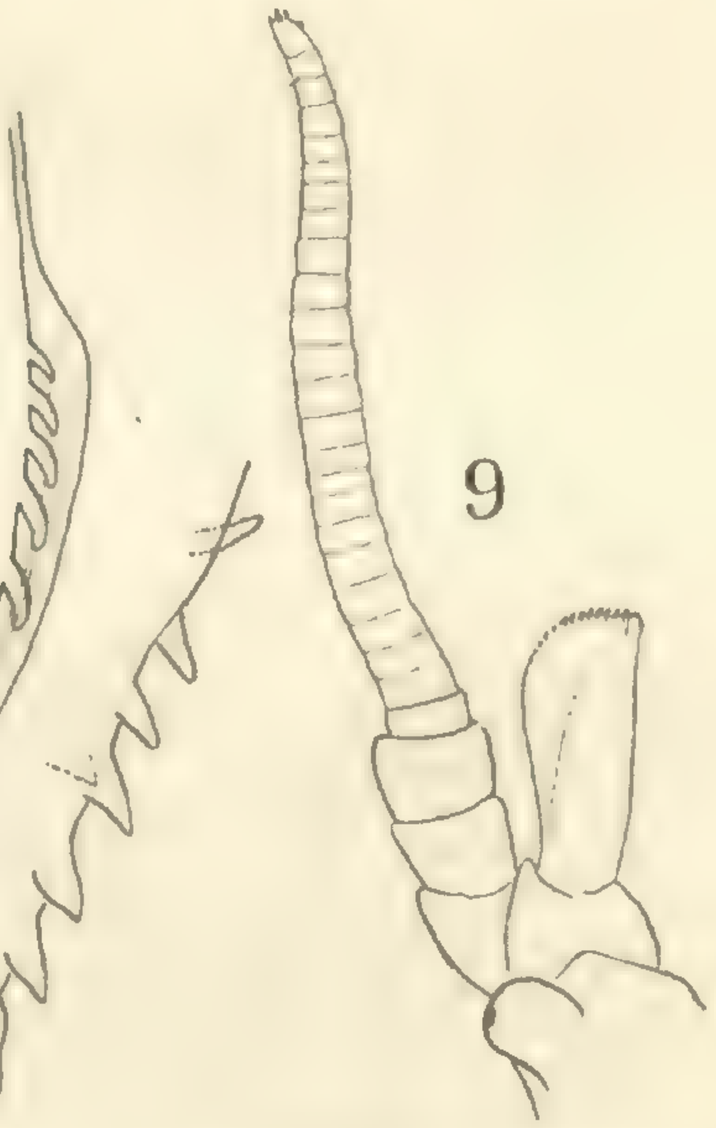
1

2



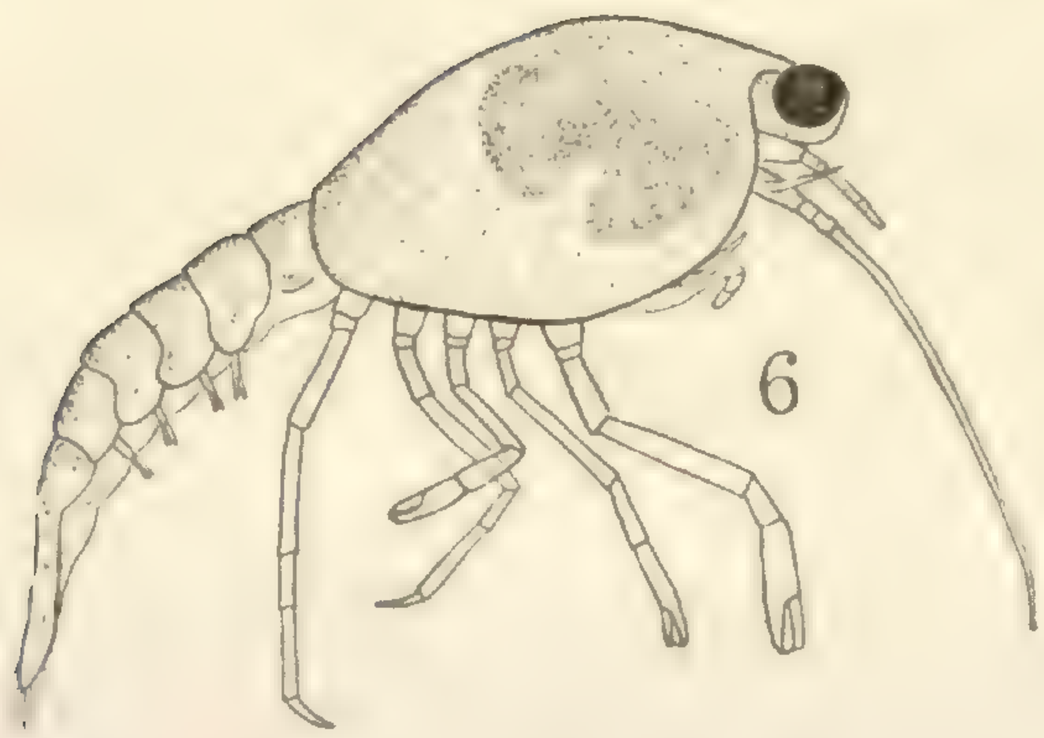
3

8



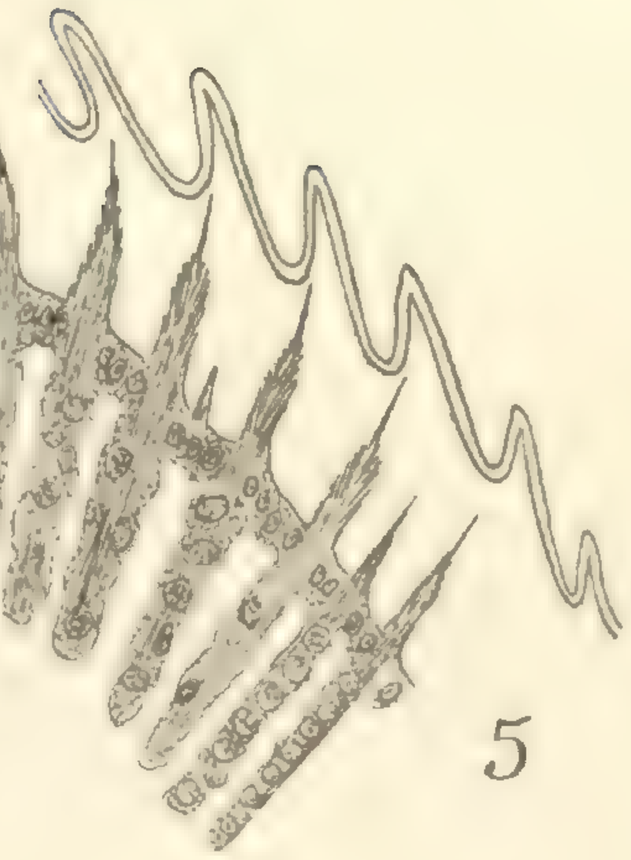
9

4



6

7



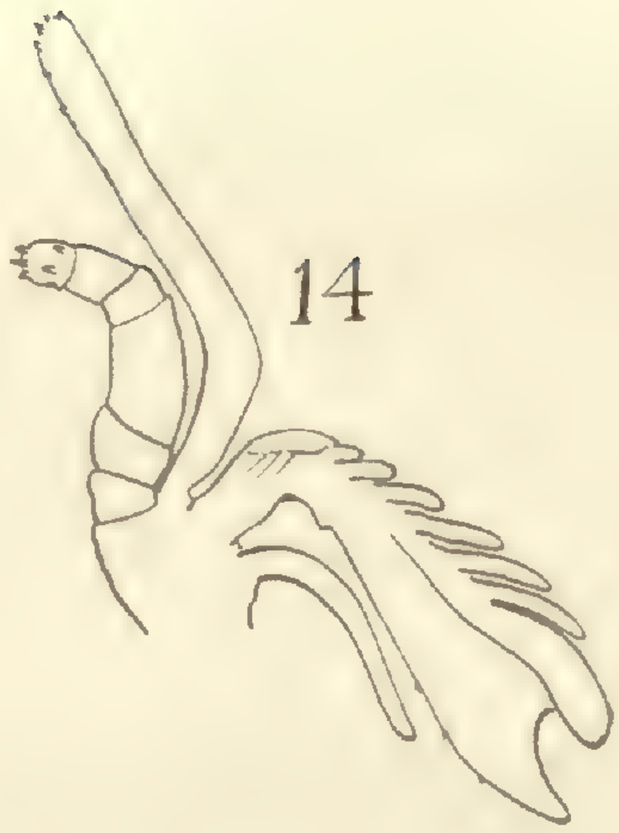
5

10

11

12

13



14

15

16

17

18

20

19

NOTES AND LITERATURE

BIOLOGY

Beebe's Log of the Sun.[1] — Merely to turn over the pages of this beautiful book dispels all desire for captious criticism. The publishers have done everything to present it to the public in the best shape while the fifty-two full page plates in color by Walter King Stone and the numerous text figures from photographs and from wash and charcoal drawings make the work a delight unto the eye. Each of the fifty-two weeks of the year has its chapter; in some cases chosen with a full appreciation of the fitness of things, in others placed in position because one week would do as well as another. Some of these chapters have previously appeared, without illustration, in other places, while others were prepared expressly for this volume. Naturally the birds attract the most attention, with the mammals a close second, but other chapters deal with reptiles, fishes and insects, while the invertebrates of the sea are not neglected and even those marvels of crystallography, the snow flakes, have their allotted space.

The text itself is written in an easy, graceful manner with a full appreciation of the wonders of nature and with the most sympathetic spirit. Here and there, perhaps, a statement is exaggerated or, may be, a slight mistake is made but these are but slight blemishes and they shall not be detailed here. Read the book, look upon the living world about you — sea, shore — plain or forest — with the open eyes of the author and you will see the marvels he has seen and a myriad others of which he tells you nothing.

Laloy's Parasitism and Mutualism. — Dr. Laloy devotes an introductory chapter of his recent work[2] to a consideration of the various reciprocal relations between living things of which series parasitism and mutualism are the opposite extremes. Following this the first part deals with parasitism under seven chapter headings: generalities,

[1] The Log of the Sun; a chronicle of Nature's Year. By C. William Beebe. New York, Henry Holt & Co., 1906, pp. xii + 345, $6.00.

[2] Parasitisme et Mutualisme dans la Nature, par le Dr. L. Laloy, bibliothécaire de l'Académie de Médecine. Préface de M. A. Giard, professeur à la Sorbonne. 1 vol. Bibliotheque Scientifique internationale; 82 text figures. 6 fr. Félix Alcan, éditeur, Paris 1906.

plant parasitism, plants parasitic on animals, animals parasitic on plants, animal parasitism, the rôle of parasites in pathology, and finally parasitism in the evolution of species. This last chapter presents in striking fashion an opinion previously advanced by this author regarding embryonic and sexual parasitism.

In the second part, devoted to mutualism, are grouped under separate chapters discussions of social life among plants, mutualism between plants and animals, social life among animals, and mimicry. Under these headings are discussed many interesting questions of an unusual sort. The author has selected instances of an illustrative type and presents them clearly and attractively.

The scope of the work is uncommonly large, embracing as it does both plants and animals and scant 300 pages are narrow limits in which to present such discussions in a form to escape criticism. To a zoologist it appears as if on the whole too great space had been given to the plant side and yet this may be distorted perspective on the part of the reviewer. The figures deal almost exclusively with plants and insects, with the former largely in the majority.

In many respects the work hardly represents present knowledge on the subjects discussed. Thus, in speaking of the hookworm, to which the author devotes a considerable section, the statements that this parasite sucks blood is perhaps excusable, though in 1903 Looss showed it to be incorrect, and this work has been much commented upon and quoted, as well as confirmed, since then. However to outline the life history with the larva encysted in a resistant envelope and infection taking place by the mouth is astonishing in view of the experimentation and discussion in this field for the past three years or more. Other statements are open to the criticism at least of serious exaggeration, such as that Yellow Fever caused one hundred deaths per annum in Havana under Spanish rule, or that in the Tæniæ one finds only internal autofecundation.

On the other hand the accounts of malarial organisms, of yellow fever and of trypanosomes are as good as could be given in the space at command. In the latter cases use was made of the admirable work of Blanchard, Laveran and Mesnil, while in the former the authority cited was not so trustworthy. In fact the author does not seem to know the literature of his subject thoroughly. He cites almost alone the French authors and does not differentiate clearly their work. Where his selection is happy the text is admirable, but at times the choice of an authority is less fortunate and the text suffers.

Some lack of knowledge shows itself also in the use of such long

since abandoned names as *Tænia cucumerina* and *Distomum hepaticum*. Better figures could have been found almost anywhere than those he gives of *Tænia solium* and tapeworm embryos; that of *Cœrurus cerebralis* is clearly wrong and the cut of a liver fluke is little more than a blotch of ink. On the other hand many of the botanical illustrations are excellent, and none are really poor. Neither authority nor credit is given for any figure, though many, if not most of them, are copied from other authors.

Despite these criticisms and an evident lack of control of his field in some places, Dr. Laloy has produced an usable work. The material brought together here is scattered widely and both unknown and inaccessible save to the specialist. The order is logical, the presentation clear and the author manifests the characteristic French ability to secure and hold the attention and interest of his readers.

GEOLOGY

Relative Geological Importance of Continental, Littoral, and Marine Sedimentation. — Professor Joseph Barrell has given us[1] a critical discussion of the conditions under which continental, littoral, and marine sedimentation take place, the classification of the three types of deposits, the evidence upon which they may be discriminated, and the probable areal and vertical extent of the deposits of each class now found in the geological column. It is shown that the littoral zone is of exceedingly small extent, its deposits less likely to be preserved than the deposits of the other two zones, and that unless a given formation is undoubtedly of littoral origin it is more likely to be either marine or continental. The regions of continental sedimentation are shown to be far more extensive than generally believed, the chances for the preservation of continental deposits often very good, and that therefore a much greater proportion of ancient sediments is likely to be found of continental origin than is generally conceded. The last part of the essay deals with the origin and preservation of mud cracks, and their value as a criterion of continental rather than of littoral sedimentation. It is shown that contrary to the usual interpretation, mud cracks generally furnish one of the surest

[1] Journal of Geology, **14**, pp. 316–356, 430–457, 524–568, 1906.

indications of the continental origin of a given formation. Applying the results of his studies to specific portions of the geological column, the author concludes that certain important formations, heretofore generally referred to a marine origin, are most probably continental deposits.

Professor Barrell's paper is an important contribution to a series of studies which are resulting in a very manifest movement away from the former tendency to regard all sediments as marine unless definitely proved of some other origin, toward a fuller recognition of the importance of continental sedimentation, and a more open attitude of mind to such an alternative interpretation.

D. W. J.

Observations in South Africa.— Professor W. M. Davis presents[1] a variety of geological and geographical observations made during his visit to the Colonies of South Africa in the summer of 1905. After a brief introduction, in which the going and return journeys are sketched, the physiographic provinces of South Africa are outlined, and the problems to be considered briefly stated. The next twenty pages are mainly concerned with a study of the Cape Colony ranges considered with special regard to their resemblance to the Allegheny mountains of our own country, both groups belonging to the class of much dissected folded mountains. The famous Dwyka glacial formation of Permian age is next discussed in some detail, some twenty pages dealing with the character of the evidence upon which reference to a glacial origin is based, the topography of South Africa during Dwyka time, and the possible causes of the Dwyka glacial period. The third portion of the paper deals with the peneplain of the Veld or interior highland, and the conditions of its origin, the evidence being weighed with a desire to discriminate if possible between normal peneplanation as one alternative, and arid leveling without baseleveling as the other. Other problems of interest, such as the origin of the zig-zag gorge below the Victoria falls of the Zambesi, and the probable greater extent of South Africa in former times, are considered. Eight plates and a number of drawings serve to illustrate the paper.

D. W. J.

Geology of the Big Horn Mountains.[2]— The results of five seasons' field work in the Big Horn Mountains of Wyoming and Montana

[1] Bulletin Geol. Society of America, **17**, pp. 377–450, 1906.

[2] U. S. Geological Survey, Professional Paper No. 51, 1906, 128 pp.

are embodied in this splendidly illustrated report by Mr. N. H. Darton. After a preliminary consideration of the geography of the region, an extended and detailed account of the various types of rocks represented in the range is given. The glacial geology is discussed by Professor R. D. Salisbury on the basis of work done by several assistants. The results of glacial erosion are very pronounced, splendid examples of cirques, U-shaped valleys, and glacial lakes being found, the amount of valley-deepening due to glacial scour being placed as high as 700 feet or possibly more in cases. The structure of the range is next considered, the uplift being in the nature of a great anticline with a somewhat prominent local dome toward the southern end, while minor flexures and faults occur. The general geologic history of the region is traced, and in conclusion the mineral resources, water supply and timber are described. Some years ago Mr. F. E. Matthes prepared an unusually valuable contour map of the central portion of the range and discussed the feature due to glacial sculpture Mr. Darton's report gives a comprehensive account of the general geology, adding much to our knowledge of this interesting region.

D. W. J.

A Glacial Lake in Tibet.— Mr. Huntington has spent several seasons in the study of geological and geographical features in central Asia, and presents in this paper[1] an account of a lake which seems to owe its origin to glacial erosion, and which closely resembles the famous valley lakes of Switzerland. According to previous observers the lake has been formed by the damming of an old outlet by fans spread out across the valley by tributary streams; but Mr. Huntington presents pretty clear evidence that the basin is terminated by a rock lip rising well above the present level of the lake, and of course much farther above the lake bottom, the lake being 142 feet deep according to F. Drew. There seems to be no evidence of warping or faulting, while the evidence of strong glaciation is abundant. The features observed would seem to indicate a true rock basin of appreciable depth scoured out by the valley glacier. Fluctuations of climate are recorded by a number of elevated beaches marking oscillations of lake level. The paper is illustrated with a map and numerous drawings and photographs.

D. W. J.

[1] Pangong: A Glacial Lake in the Tibetan Plateau. By Ellsworth Huntington. Journal of Geology, Vol. 14, 599–617, 1906.

ZOÖLOGY

A Statue of Lamarck.— As yet there is no memorial to this eminent naturalist but now it is proposed to erect one in the Jardin des Plantes in Paris. The matter is in charge of a committee of the Museum d'Historie Naturelle in Paris; subscriptions may be sent to Professor Joubin, the secretary, 55, Rue de Buffon, Paris, France.

Gardiner's Maldive and Laccadive Archipelagoes,[1] parts of which have been noticed in these pages as they have appeared, has now been completed. The whole makes two quarto volumes of 1079 pages and 100 plates. In this concluding part is an account of the Myriapoda collected by R. I. Pocock enumerating eight species, and some supplementary remarks upon geographical distribution and comments upon the coral reefs, apropos of Mr. Agassiz's work in the same region.

Kollmann's Atlas of Human Embryology.[2] — This is, as its name implies, an atlas of development. There is no true text, merely descriptions of the three hundred and forty figures which are intended to illustrate the features of human embryology. These figures, which are in part printed in tint, in part in color, are of varying degrees of artistic excellence and have been taken from various sources, a goodly proportion of them being original. Those in half-tone made from wash drawings are with few exceptions excellent, while those made by the zinc process are usually more crude. In a few cases other animals than man have been called upon to supply the illustrations. Thus the early phases of the mammalian orums are based upon Sobotta's well known figures of the egg of the white mouse; Bonnet's work upon the dog and Selenka's upon the apes are called in to illustrate other early features; while chick and fish furnish illus-

[1] The Fauna and Geography of the Maldive and Laccadive Archipelagoes edited by J. Stanley Gardiner, Volume 2, Supplement 2, Cambridge [England] 1906. 3s, 6d.

[2] Handatlas der Entwicklungsgeschichte des Menschen von Dr. Julius Kollmann, Erster theil; Progenie, Blastogenie, Adnexa Embryorum, Embryologia Osseum, Embryologia musculorum. Jena, Gustav Fischer, 1907. Mk. 15, Gebunden.

trations of monstrosities, and the development of the skull is introduced by Schauinsland's figures of Callorhynchus, and Stöhr's of the salmon.

While the work has considerable value for the medical student in that the illustrations supplement those of the usual text book, the morphologist finds the volume less adapted to his needs. One might wish figures showing the early stages of the vertebral column, more details regarding the development of the lower jaw, better illustrations of the embryonic adnexa, and some connection between the figures of the head cavities and the definitive eye muscles which develop from them. Three figures illustrate the development of the diaphragm. In two only the septum transversum is shown; in the third the diaphragm has nearly its definitive condition, but there is nothing to show the origin of the 'pleural portion.'

The Systematic Position of the Tubinares.— In a recent number of this journal (**41**, p. 111, 1907), Dr. Shufeldt in the historical introduction to his paper 'On the osteology of the Tubinares,' has this to say about my treatment of these birds in the Standard Natural History, vol. IV, pp. 84, seq., (Boston, 1885): "This writer places in his scheme the Tubinares widely removed from the Steganopodes, which I believe to be a mistake, and a non-appreciation of the morphological characters of the latter group of Birds."

If the main object of the bird volume of the Standard Natural History had been to present a new classification which in all details should represent my own ideas, the position of the Tubinares would have been a different one. That I fully indicated their proper place and also fully appreciated their 'morphological characters' will be apparent from a perusal of the following quotations from my work: "The arrangement may not be regarded as final, however, for there are reasons to suspect that it will be necessary, ere long, to divide the schizognathous swimmers into three orders, Eretmopodes for the first two superfamilies of the present arrangement, Tubinares for the superfamily Procellaroideæ, and Pluviales for the rest." (P. 65.)

"It has already been hinted at, on a previous page, that the superfamily Procellaroideæ might perhaps better constitute a separate order, Tubinares. Their differences from all the foregoing birds are many and important, and their affinities seem to be more with the Steganopodes and Herodiones than with the gulls or the auks, to some of which many of the petrels show a remarkable external and superficial resemblance." (P. 84.)

And finally, on page 85, I again emphasized the true position of these birds by reiterating that it is "rather probable that the Tubinares should be placed in the neighborhood of the Steganopodes and Herodii."

Professor Fürbringer, in his last review of this subject (Jena. Zeitschr. Naturw., **36**, pp. 644–646, 1902), does full justice to the subject as follows: "Stejneger–Cope ('85/'89) follow Huxley in the rather unfortunate establishment of the Cecomorphæ, but Stejneger mentions particularly that the Tubinares perhaps are better regarded as a special ordo with nearer relation to the Steganopodes and Herodii. . . . On the strength of later considerations I still adhere essentially to the opinion expressed by me in 1888, but I am inclined to place their relationship to the Ciconiiformes more in the foreground and that to the Laro-Limicolæ more in the background than then. . . . On the other hand, I cannot follow those authors who argue for placing them too far from the Laro-Limicolæ," the group called *Pluviales* by me in my first quotation above from the Standard Natural History.

LEONHARD STEJNEGER.

Beebe's The Bird[1] in the American Nature Series is easily one of the most useful as well as one of the most interesting books which this epoch of bird books has produced. It marks, we hope, the beginning of a new period in amateur bird study, a period when many of those who now keep bird lists as a pastime will take up the serious study of the bird itself. The book contains seventeen chapters, the titles of some of which are as follows,— The Framework of the Bird, The Skull, The Food of Birds, The Senses, Beaks and Bills, The Eggs of Birds, etc.

Mr. Beebe is curator of birds in the New York Zoological Park. His position has enabled him to observe at close range the habits of a great variety of birds, and also to discover the needs of an inquiring public. Mr. Beebe is, however, much more than a keeper of animals; he is a trained scientist and a skilful lecturer. He has succeeded in this book in arranging a large amount of accurate information clearly and forcibly, and to present it in such a way as to arouse and hold the reader's interest.

The value of enlarging the amateur student's horizon is constantly

[1] Beebe, C. William. The Bird. Its Form and Function. New York, Henry Holt & Co. x + 496 pp. 371 figures.

in the author's mind. The first chapter, therefore, presents the essential facts which palæontology contributes to our knowledge of the bird, and throughout the book there are frequent and illuminating references to homologies or analogies in the kindred classes. The delicate balance of Nature and the complex interrelations of all organic life are well illustrated in the chapter on food.

Where a large number of forms are discussed it is difficult to avoid the appearance of a mere catalogue of compiled facts. Evans' Dictionary of Birds is a noticeable example of work of this kind. Mr. Beebe has avoided this danger by a happy introduction from time to time of bits of personal observation, or by enlarging on some exceptionally interesting habit or structure. The reference to a flamingo observed by Mr. Beebe, weeping from terror because a condor was playfully "galloping" around it, illustrates also the author's happy choice of words.

The suggestion of problems to the solution of which careful observers can bring assistance, the frequent references to Nature's evasions of our pet theories, and the conservative position taken on disputed points, begets in the reader a strong and deserved feeling of confidence that Mr. Beebe possesses together with his power of picturesque presentation the wide knowledge and sound judgment of a trained scientist. Mr. Beebe is evidently a strong believer in sexual selection, but he puts forth (p. 318) an interesting suggestion that the display of the male bird instead of affecting the æsthetic sense of the female may induce some sort of hypnotic condition. In the chapter on The Body of the Bird (pp. 292–295) there are some interesting observations on color changes due directly to environment or food. White-throated sparrows and wood thrushes turned almost black when confined in a bird house where the air was constantly moist.

The book is extremely rich in illustrations, chiefly photographs of great clearness and beauty taken from life by the author. Their excellence adds much to the attractiveness of the work, and the skill with which they have been selected and arranged is evidence of the author's gift as a teacher. There is an excellent index, and a brief list of useful books.

Though primarily intended for the instruction of amateurs, Mr. Beebe's book is one that will at once win an honorable place in the library of every teacher of natural history. No public library or school should be without it. It will be the hope of all who use this manual, that Mr. Beebe will follow it by a similar treatment of the intelligence of birds.

R. H.

The Conus Arteriosus in Teleosts.— One of the characters which have been relied upon to distinguish Ganoids from Teleosts has been the presence in all Ganoids and, with the exception of Butirinus, its absence from all of the other group. H. D. Senior now shows[1] that the tarpon of our southern waters has a conus with two rows of valves.

Does half of an Ascidian Egg give rise to a whole Larva?— In reply to criticisms of Driesch, Conklin returns to this question which was discussed in his earlier papers and maintains (Archiv f. Entwicklungsmechanik, **21**, 1906) the general correctness of his former account. The half blastomere cleaves as if it were still part of the entire egg; correspondingly the resulting gastrulæ are half gastrulæ and are in no wise bilaterally symmetrical and the anlagen of muscles and mesenchyman unilateral in position. Similarly the larvæ up to the time of metamorphosis are half larvæ, having only the parts belonging to one side—right or left—represented. They "are such as would result if a fully formed larva were cut in the median plane and the cut edges of each half then came together, the dorsal and ventral mid-lines joining. These results follow from the early differentiation of the organ-forming substances in the egg.

Digestive processes in Collembola.— Dr. J. W. Folsom and Miss M. U. Welles have studied the digestive processes in the mid-gut of Tomocerus and other Collembola.[2] They deny the existence of Malpighian tubules in these insects and note the fact that they molt throughout life. In connection with each ecdysis there is a degeneration of the inner half of the intestinal epithelium, the degenerate portion being cast out soon after the molt, carrying with it a part of the nuclei which are replaced mitotically from those which persist. In this degenerating mass is contained sodic urate as well as gregarine so that this is an excretory process. Adult specimens molt every six or eight days; the cast skin is devoured.

Fresh Water Amphipods of North America.— Miss Ada Weckel furnishes a valuable synopsis[3] of these forms. In all eighteen species are described, two (*Gammarus ramellus* from California and *G. cæcus* from Cuba) being new. The author seems to have overlooked

[1] Biological Bulletin, **12**, 1907.
[2] University [of Illinois] Studies, **2**, no. 2, 1906.
[3] Proc. U. S. Nat. Mus., 32, 1907.

the description of *Crangonyx knoxensis* by O. P. Hay printed (June 27, 1878) on the extras of Dr. Hay's reprint of his "Description of a new species of Asellus" from the Bulletin of the Illinois State Laboratory of Natural History, No. 2. This reprint, by the way, possesses a plate, illustrating *Asellus militaris*, *Crangonyx knoxensis* and *C. gracilis* Smith, which does not appear in the Bulletin.

Some Problematic Worms.— Schepotieff has a valuable systematic paper[1] on the interesting worms of uncertain affinities grouped as Desmoscolicidæ, Echinoderidæ, Chætosomatidæ, and Rhabdogaster and Trichoderma. The article begins with some interesting conclusions as to geographic and bathymetric distribution and then proceeds to the description of the species, illustrated by good figures, in which numerous new forms are recognized.

C. Davidoff thinks[2] that he has found evidences of a true mesoderm in the larva of the Narcomedusan jelly fish Solmundella. Photographs of sections which he gives show a distinct cell-layer between ectoderm and entoderm, not the structureless mesogloea usual in that position. If this interpretation be correct, it will, as Davidoff remarks, remove one of the objections to a close association of Ctenophores with the Cnidaria.

Leisenitz has studied[3] the chitinose spines occurring on a number of insect larvæ which serve as organs of locomotion. Numerous zinc etchings illustrate the kinds of spines and their arrangement. The results are not readily summarized and have little systematic importance.

Forbes' Keys to Lepidoptera and Caterpillars[4] will doubtless prove of value to beginners in the study of the butterflies of New England, while others will find the keys to the larvæ of use. First in order is a list of butterflies and larger moths with size and color markings, food plants of the larvæ, dates of imago, number of broods and haunts; next a key based upon color of the species of large Lepi-

[1] Zoologischer Anzieger, **31**, p. 132, 1907.
[2] Zoologischer Anzeiger, **31**, p. 119, 1907.
[3] Ueber chitinöse Fortbewegungs—Apparate einiger Insektenlarven. München, 1906.
[4] Field Tables of Lepidoptera by Ww. T. M. Forbes, Worcester, Mass., 1906, pp. 141.

doptera found in New England. The second portion (over half) is given to a key to the caterpillars of all but the smaller Lepidoptera of the same region.

J. F. McClendon has described four new species of Myzostoma (Proc. U. S. Nat. Mus., 32, 1907, obtained from the collection of crinoids in the National Museum.

BOTANY

Sukkulente Euphorbien.[1]—This is the first of a series of illustrated handbooks of succulent plants designed by the author to meet the demand that the scattered literature should be brought together in a form accessible to the many cultivators of this group of plants. The aim is to give both a scientific classification and cultural hints on those species now in cultivation and this work has been admirably done, both in the text and in the numerous half-tone illustrations.

One hundred and nine species and eight varieties of Euphorbias are treated, nine species and two varieties being new to science and three species have been renamed. The species listed are for the most part natives of Africa, though a few are from the adjacent islands and from India, and three are American. A good working key is given to the twelve sections under which the species are arranged and the sections again are each provided with good comprehensive keys so that a species may be readily determined. The descriptions are full and clear, supplemented by full synonymy and by additional notes on habitats and comparisons between species, ending in a short note on the culture required for the species. Following the treatment of species a chapter is devoted to the general culture required for this group of succulents and the text ends in a full index to the literature bearing on the group.

In view of the fact that several new species appear in the publication it may be well to state that, though the title page bears the date of 1907, copies have been distributed in December 1906.

C. H. THOMPSON.

[1] Berger, Alwin. *Sukkulente Euphorbien.* Stuttgart, 1907. 12 mo. v + 135 pp. 33 Abb.

(No. 483 was issued March 29, 1907)

The first of a series of Colored Plates of the

THRUSHES OF NORTH AMERICA

By FUERTES & HORSFALL,

was published in BIRD-LORE for February.

The series will be concluded this year

---

20 CENTS A COPY. $1.00 A YEAR

THE MACMILLAN CO.

NEW YORK CITY

The Great English Magazines

DO YOU know them—know what they are publishing—read them—subscribe for them? There are THE EDINBURGH REVIEW and the QUARTERLY; the CONTEMPORARY, FORTNIGHTLY, MONTHLY, INDEPENDENT, WESTMINSTER, and NINETEENTH CENTURY REVIEWS; BLACKWOOD'S, CORNHILL, MACMILLAN'S, GENTLEMAN'S, and PALL MALL MAGAZINES; the SPECTATOR, the SATURDAY REVIEW, the SPEAKER, the OUTLOOK, PUNCH and others. No matter how many American magazines you read, you need to know something of our English contemporaries. The one convenient, sensible, inexpensive way is to subscribe for **The Living Age,** which gives every week the best contributions from current numbers of the foreign periodicals. Its scope includes literature, science, history, politics—especially timely discussions of public affairs; travel and exploration: essays, reviews and criticisms; fiction—both serial and short stories. President Roosevelt, Chief Justice Fuller, and thousands of other people who want to be cosmopolitan in their reading are subscribers for **The Living Age.** Founded in 1844. $6 a year, $1 for 3 months' trial. Specimen copy free.

ADDRESS

THE LIVING AGE CO.

6 Beacon Street, . Boston, Mass.

VOL. XLI, NO. 485 MAY, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	The Functions of the Spiracle of the Skate	HERBERT W. RAND	287
II.	A Critical and Statistical Study of the Determination of Sex, particularly in Human Offspring	F. H. PIKE	303
III.	Chubs' Nests	ALFRED W. G. WILSON	323
IV.	Notes and Literature: *General Biology;* Mendelism.—The problem of age, growth and death.—The hypothesis of mimicry. *Zoology;* Palms and Soles.—Literature of Ichthyology.—Nettling hairs of the brown-tail moth.—Divided eyes of insects.—Notes. *Botany;* Winter rest.—Notes		329
V.	Correspondence: The Flying Fish Problem		347
VI.	Publications Received		349

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology, Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *May, 1907* No. 485

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L MARK, DIRECTOR. No. 189.

THE FUNCTIONS OF THE SPIRACLE OF THE SKATE

HERBERT W. RAND

IN the latter part of September, 1904, I spent a few days at the Woods Hole laboratory of the United States Bureau of Fisheries for the purpose of making a study of certain blood vessels of the skate. At that late season the Fisheries laboratory had abandoned its fish traps and I was supplied with material through kindness of officials of the Marine Biological Laboratory, which was still maintaining a trap in Vineyard Sound. One afternoon this trap was hauled and some seven or eight common skates (*Raja erinacea*) were taken. The skates were thrown with numerous other fish into the bottom of a skiff which was towed back to the laboratory by the steam launch,— a distance of about a mile. Arrived at the laboratory, I picked out the skates and threw them into a large shallow tank for the purpose of washing from them the sand and debris which had become attached to them in transit. In view of the fact that the fish had been out of the water nearly an hour and had been subjected to no very careful treatment, it did not occur to me but that they were dead, or at least beyond the possibility of reviving. By means of a hose I turned upon them a copious stream of cold sea water and then I noticed, for the first time, that feeble respiratory motions were in progress. As I continued to play the water over the fish the respiratory motions became stronger. Shortly one skate slid over the opening of the

outlet of the tank, closing it, and in a few moments a half inch of water had accumulated over the bottom of the tank. Thereupon the skates set up an energetic spouting of water from the spiracles, — a mode of behavior which had never before come to my notice. At frequent intervals a large stream of water was ejected from each spiracle, rising vertically to a height of one or two inches. (The fish were of uniform size,— about a foot in width across the pectoral fins.) The animals were not submerged, it should be remembered, but were less than half covered with water, most of the dorsal surface, including the spiracular region, being well out. The vigor and frequency of the spouting and the fact that so many skates were doing it at the same time produced an effect striking enough to compel attention. No doubt this behavior has been observed previously by others. A "Spritzloch" is certainly a spout-hole. But I could recall having met only the briefest reference to the use of the elasmobranch spiracle in respiration, so I postponed the fate of some of the skates and placed them in an aquarium supplied with running sea water, with a view to watching their respiratory movements. During the next few days I observed the fish as I could, but other work had precedence, so that I was unable to carry on any systematic study of their behavior. However, my impromptu experiments brought to light one or two facts which seem to me worthy of mention.

As must be well known, the modified first visceral cleft (spiracle) serves in the skate chiefly as an incurrent opening for the respiratory stream. So far as this function is concerned, as pointed out by Garman ('74), the spiracle is probably of greater importance in the rays than in the sharks, owing to the fact that the rays, for the most part, lie flat upon the bottom of the sea, and this habit places the mouth at a disadvantage as an incurrent respiratory opening, while in the perpetually roving sharks such is not the case. These facts are very likely connected with the fact that the spiracles occur as large openings in all the rays while in many of the sharks they are either very small or completely closed.

Many writers make the statement that water may pass either into or out from the mouth by way of the spiracle. Garman ('74) notes that, whereas the sting-rays have in the spiracular passage a valvular fold preventing outflow, in the common skate no such

structure is present, so that water may pass either way. Duméril ('65–70, tome 1, p. 210) states that water usually enters the mouth through the spiracle, but less frequently passes in the reverse direction.

While at rest on the bottom of an aquarium, the skate slightly elevates the head above the surface of the bottom in the manner described in Brehm's Thierleben (Brehm, '79, p. 387), which may well be quoted : "Abweichend von anderen Bodenfischen liegen sie mit dem Vordertheile ihres Leibes niemals fest auf, sondern stützen sich so auf ihre Brustflossen, dass in der Mitte ein Hohlraum bleibt." Continuing, Brehm's account says, "Um die Kiemen mit Wasser zu versorgen, öffnen sie ihre Athemlöcher, indem sie den Kolben zurückziehen, füllen die Kiemensäcke, schliessen die Athemlöcher und treiben das verbrauchte Wasser durch die Kiemenspalten nach aussen." According to my observations the skate takes in water not only by the spiracle but also through the mouth, although considerably more water enters through the spiracle than through the mouth.

When fully open the external aperture of the spiracle in the common skate is nearly elliptical in outline, but the curvature of its anterior margin is much greater than that of its posterior margin. The anterior lip of the opening bears the rudimentary gill and the closing of the spiracle is effected mainly by the contraction of this gilled lip, while the posterior lip, being nearly straight when relaxed, contracts but little.

In ordinary respiration the spiracle opens and closes with pendulum-like regularity. During one of the prolonged resting periods of the fish, the interval between successive openings is longer than when the fish is active, and the spiracle is not opened wide,— indeed, the opening may be only a narrow slit. During more active respiration the anterior lip of the spiracle moves back and forth with a quick decisive motion and the spiracle is opened to its utmost width. As the spiracular valve opens, the branchial region is expanded and a strong current of water is drawn in through the spiracle, the external branchial apertures meanwhile being tightly closed. At the same time that the spiracle is open, the mouth also is opened more or less and a certain quantity of water enters. I satisfied myself as to the inward current at the mouth

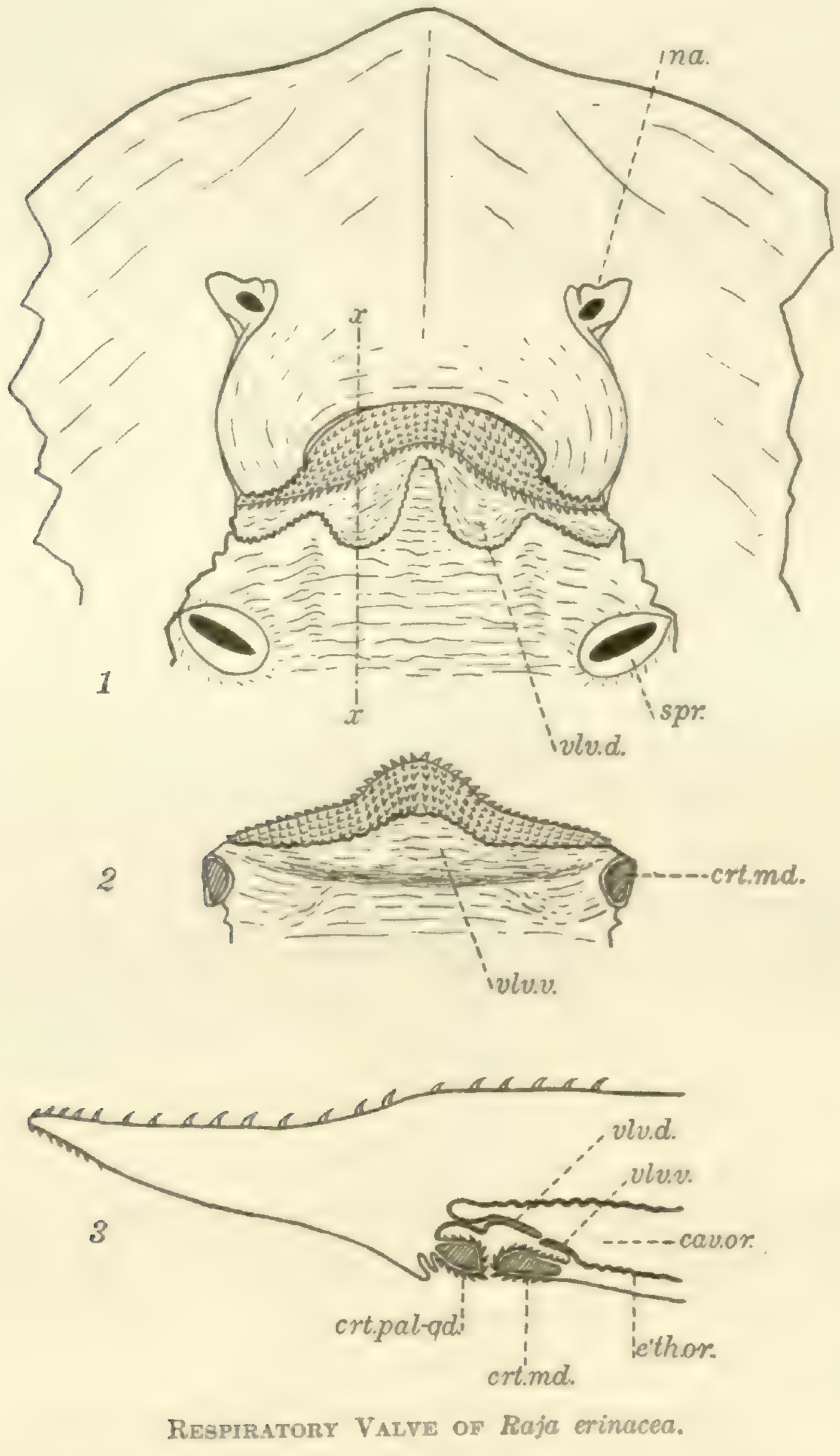
by watching the movement of solid particles suspended in the water in the vicinity of the mouth. Much the greater volume of water, however, appears to enter through the spiracle.[1] During an expiration the spiracle is shut, while the mouth tends to close but does not close tightly. The mouth action was always a little sluggish as compared with the action of the spiracle, especially in opening. As nearly as I could determine, mouth and spiracle closed together, but the opening of the mouth was slightly later than that of the spiracle. As spiracle and mouth close, the branchial region is contracted and the water contained in the gill chambers is forced out through the gill clefts.

That water does not flow out through the mouth as well as through the gill clefts during an expiration is probably due to the action of a well developed respiratory valve similar to those described for teleosts by Dahlgren ('99). The dorsal flap of the valve (Figures 1 and 3, *vlv. d.*) is a conspicuous bilobed fold of the oral membrane, while the ventral or mandibular flap — a less extensive fold — is broadest in the median region of the lower jaw and becomes much narrower towards the sides of the mouth. Judging from the relative widths and the positions of the two parts of the valve, it appears that the prevention of outflow through the mouth must depend mainly upon the action of the dorsal flap. Garman ('74) mentions only the dorsal one of these two folds.

The elevation of the forward end of the fish above the surface on which it rests would seem to facilitate the respiratory process.

[1] To observe these respiratory movements I put a fish in a large rectangular flat-bottomed glass vessel. The vessel was placed upon a high table so that one end projected some distance beyond the edge of the table. The fish was induced to lie with its head in the overhanging part of the vessel. I found that an object held just underneath the mouth could be seen directly through the head of the fish by looking, at the proper angle, into the spiracle as it opened, and, similarly, an object held just above the spiracle could be seen by looking upward into the mouth as it opened. This was sufficient proof that mouth and spiracle were open at the same time. In order to see the dorsal and ventral surfaces of the head at the same time so that the action of spiracle, mouth and gill clefts could be observed simultaneously, I viewed the spiracle by total reflection from the surface of the water. Having the water at a certain depth and looking upward from underneath the overhanging vessel at just the proper angle, I could see by reflection the dorsal surface of the head with sufficient clearness, while at the same time I had a direct view of the ventral surface of the head.

Is the spiracular current ever reversed — that is, does the spouting occur — in normal respiration? To answer this question



RESPIRATORY VALVE OF *Raja erinacea*.

FIG. 1.— Ventral aspect of the head of a skate, the lower jaw and floor of mouth having been removed so as to show the roof of the mouth and the dorsal flap of the respiratory valve (*vlv. d.*). *na.*, nostril; *spr.*, oral aperture of spiracle.

FIG 2.— Lower jaw and anterior part of floor of mouth, showing the ventral or mandibular flap of the respiratory valve (*vlv. v.*). *crt. md.*, cut end of mandibular cartilage.

FIG. 3.— Parasagittal section of the jaws at the position of the line *x x*, Figure 1. *cav. or.*, mouth cavity; *crt. md.*, mandibular cartilage; *crt. pal-qd.*, palato-quadrate cartilage; *e'th. or.*, oral epithelium; *vlv. d.*, dorsal flap, and *vlv. v.*, ventral flap, of respiratory valve.

I watched the respiration of skates in aquaria supplied with running water, observing the fish at times when they had not been disturbed in any way for several hours. At such times the rate of respiration was always slow,— usually from 22 to 30 inspirations per minute. At fairly regular but long intervals there occurred a break in the regular alternation of inspiration and expiration. This break was brought about in the following way. Immediately after an inspiration (and therefore in a period ordinarily marked by a contraction of the pharynx with closed spiracle and open gill clefts) the spiracle remained open and the gill clefts remained tightly closed while a particularly vigorous contraction of the pharynx caused the contained water to be ejected forcibly from the spiracle. It is apparently by muscular action that the gills are kept closed during the spouting, since the pressure of the water in the gill chambers would tend to force open the external valves. During the spouting the mouth was open, as it is during inspiration, and some water escaped from it, but very little as compared with the amount ejected from the spiracle. It is doubtless due to the respiratory valve that the outflow from the mouth is not greater. The contraction which caused the spouting was immediately followed by an expansion of the pharynx, the spiracle still remaining open and the gill clefts closed, and respiration then proceeded in the usual way. In animals which had been at rest for several hours, the rate of respiration being then at its lowest, the spouting occurred at intervals of five to ten minutes.

Having found that spouting is a feature of normal respiration in a resting fish, I next sought to discover what part the spouting plays in the respiratory process. With this end in view, I observed the fish under other conditions than rest.

Effects of Exercise.— The rate of respiration in a fish varies with the degree of activity. To induce rapid respiration I caused the fish to take exercise. This was effectively done by grasping and holding the skate firmly by the tail. The most violent efforts are made to swim away from the detaining grasp. Following are accounts of several experiments in which the rate of respiration was caused to vary.

(1) A skate had been undisturbed over night in an aquarium supplied with running sea water. When first observed in the

morning the fish was at rest, the respiration being very slow and the spouting infrequent, as described above for the resting condition. I have no record of the precise rates in this case. The fish was then exercised and immediately removed to a shallow tray of water for easier observation. The rate of respiration was markedly increased, rising to 47 inspirations per minute, and a spouting occurred on the average after every nineteenth inspiration, that is, a little oftener than twice a minute. This average was obtained by counting the number of inspirations within a period covered by eleven successive spouts. The actual number of inspirations between two successive spouts varied from 15 to 23.

In a similar case the rate of respiration while at rest was 22 inspirations per minute, with spouting at intervals of several minutes. After exercise the rate of respiration was 39.5 per minute, with a spouting after every seventeenth inspiration, or at the rate of 2.3 spouts per minute.

(2) A skate which had been undisturbed, so far as I know, for two days was found resting quietly against the side of the aquarium. The rate of respiration and the frequency of spouting were determined. Then the fish was exercised vigorously for five minutes, after which it was given five minutes to become quiet so that observations could be made. Following are the results of the experiment.

	No. of Inspirations per Minute	No. of Inspirations between Spouts	No. of Spoutings per Minute[1]
Resting	30	246	0.12
After exercise	47.5	67	0.71
Increase	58%		500%

(3) A skate which had been under experiment was allowed to rest for about an hour. At the end of that time the rates of respiration and spouting were determined. Then during the next half hour the fish was subjected to some annoyance by irritation

[1] The rate of spouting is thus expressed for the sake of ready comparison with the rate of respiration (first column). Thus, a spouting rate of 0.12 means that the spouting occurred at intervals of about eight minutes.

of the spiracle and neighboring parts (see page 299). After these experiments the fish was exercised vigorously for a minute or so, after which the rates were again observed. Following are the results of the experiment.

	No. of Inspirations per Minute	No. of Inspirations between Spouts	No. of Spoutings per Minute
Immediately after one hour's rest	47	55	0.85
After a half hour's annoyance, followed by brief violent exercise,	63	42	1.5
Increase	34%		77%

The high respiratory rate (47) immediately after the hour's rest apparently means that the fish had not recovered from the effects of the experiments which preceded that hour, a rate as high as 57 having been induced in the course of these experiments.

(4) In a skate immediately after exercise, conditions were as shown in the following table.

	No of Inspirations per Minute	No. of Inspirations between Spouts	No. of Spoutings per Minute
(a)	49.5	49	1.0

This skate was then left undisturbed about three hours in a small vessel of water, which was not changed during that time. At the end of the three hours the rates were as follows.

	No. of Inspirations per Minute	No. of Inspirations between Spouts	No. of Spoutings per Minute
(b)	39	78	0.5
Decrease in rates, comparing (b) with (a)	21%		50%

Immediately after the record (b) was obtained, the fish was exercised and put into well aerated water. After five minutes (to allow the fish to become quiet enough for observation) the conditions were:—

	No. of Inspirations per Minute	No. of Inspirations between Spouts	No. of Spoutings per Minute
(c)	49	22.5	2.2
Increase in rates, comparing (c) with (b)	26%		340%

In this experiment the rates of respiration and spouting are influenced by two factors, exercise and the quality of the water, and the effects of these two factors can not be separated in the results. The experiment is cited because it shows strikingly, and in accord with other experiments, that, as the rate of respiration rises and falls, the rate of spouting likewise rises and falls, but in much greater proportion.

(5) Another observation shows the effect of quiescence. A skate immediately after exercise breathed 40 times per minute and spouted twice per minute. After three hours' quiescence (during the first hour of which the fish was extremely restless), the frequency of breathing had *decreased* 44%, while the frequency of spouting had decreased 68%.

In several other experiments similar to those just described the same general results were obtained. Fish which had been resting quietly for several hours were found to breathe from 22 to 30 times per minute, while the spouting occurred at intervals of several minutes. After vigorous exercise the frequency of breathing was always increased to a rate between 40 and 60 per minute and the spouting occurred once per minute or oftener. Thus, when the rate of respiration becomes more rapid as the result of exercise following a period of rest, the frequency of spouting is increased also, *but in much greater proportion*. A very rough average, from all of the observations taken together, shows that, whereas the rate of respiration is increased about 100%, the rate of spouting is increased at least 500%.

With quiescence, the rates of respiration and spouting drop towards the low resting rates, but the spouting rate falls off relatively much more rapidly than the rate of breathing.

Effects of Partial Asphyxiation.— Is the frequency of spouting affected by partial asphyxiation? The behavior of the fish when first brought into the laboratory suggests this question. The following experiments were made.

(1) A skate was put into a rectangular glass vessel measuring about 12 by 18 inches, containing sea water to the depth of about 3 inches. The fish was allowed to become quiet and then was left undisturbed for two hours, during which time a copious stream of water was flowing into the vessel. At the end of this period the animal was found resting quietly, respiration being at the rate of 22 per minute, while spouting occurred at very irregular intervals averaging about 1⅓ minutes.

The stream of running water was now shut off and the fish was left in the vessel without change of water for about three hours. During the earlier part of this time there were alternate periods of quiet and unrest. In one of the periods of quiet, the respiration was slow and the spiracle was only slightly opened. But after a minute or two of these resting conditions, respiration became markedly quickened, the spiracle being opened wide at each inspiration, and shortly the fish raised its head and began to swim about, usually trying to swim up the low vertical side of the aquarium so that the head was thrust out of the water. This activity lasted usually less than a minute, after which the fish dropped to the bottom of the aquarium and became quiet, the respiration at once slowing down to the normal resting rate. Sometimes the performance was varied in that the quickened respiration which marked the close of an interval of rest was followed, not by the swimming activity, but by a vigorous spouting, after which slow respiration was resumed. At still other times the period of unrest was marked by both the swimming and the spouting. Occasionally the spouting occurred also in the resting intervals.

During the second hour after the incurrent stream of water was shut off the alternate periods of rest and unrest continued. The rate of respiration, however, gradually increased, reaching a maximum at the end of the second hour when the fish was breathing 59 times per minute and spouting about once per minute. Respiration was equally rapid during rest and unrest. The activity was often much more violent than in the first hour of the experiment.

In the third hour of the experiment the rate of respiration diminished with increasing rapidity. Following is the record (the running water having been shut off at 1.00 P. M.).

3.00	P. M.	Rate	of	respiration	59	per	minute	
3.20	"	"	"	"	57	"	"	
3.45	"	"	"	"	50	"	"	
4.00	"	"	"	"	40	"	"	

The spouting continued at the rate of about once per minute. The resting periods were considerably longer than in the preceding hours and the activity was less violent. The fish evidently was becoming sluggish. Returning at 4.10 to observe the fish, I found the respiration obviously much slower and rapidly diminishing in frequency. Before I could determine the rate the respiratory motions suddenly became very irregular and spasmodic and then the action of the spiracle abruptly stopped. I waited, perhaps half a minute, and then, fearing a premature end to the experiment, I turned into the aquarium a stream of water, washing it about the head of the fish. Within a minute feeble and slow respiratory movements began, *shortly followed by four vigorous spoutings in rapid succession*. Respiration quickly became stronger and its rate increased rapidly, reaching 48 per minute at 4.22 o'clock. The rate of spouting, at the same time, was 1.5 per minute, an increase of about 50% over the rate at 4.00 o'clock.

At 4.29 the fish was taken out of the water and left lying on the table top. For several minutes it struggled vigorously, but at the end of eight minutes the respiratory motions had ceased and there was little muscular reaction anywhere — the fish was quite limp. The heart, however, was beating strongly. Then the animal was put into well aerated sea water. At first no sign of returning activity appeared. The spiracle was wide open and motionless. I therefore began kneading the gills and directed a stream of water into the spiracle. Almost immediately very weak, slow and irregular spiracular motions began, and in the course of two minutes regular respiratory movements were in progress, although still weak and very slow. The spiracle did not close tightly, so that some water escaped from it at each expiration. This was not regarded as spouting. The action of the spiracle rapidly quickened and strengthened, and about four minutes after the fish was returned to water I began to count the rate of spouting which was then occurring frequently. The count was made through three successive minutes. During the first minute

the spouting occurred five times, while for the entire period of three minutes there were, on the average, four spoutings per minute. At the end of the three minutes the rate of respiration was found to be 41 per minute.

(2) Following is the record of another experiment.

10.00 A. M. A skate was removed from the water.

11.15 A. M. Feeble respiratory motions of gill chambers and spiracles still in progress at the rate of 28 per minute. The spiracle is continuously wide open, its anterior lip contracting very slightly at each expiratory movement. The mouth is continuously shut.

11.20 A. M. The skate is put into well aerated sea water.

11.21 A. M. The spiracular action is stronger and weak mouth action begins.

11.25 A. M. The spiracle closes completely at each expiratory movement.

	Inspirations per Minute	Inspirations between Spouts	Rate of Spouting
11.30 A. M.	35	25	1.4
11.39	41	39	1.0
11.47	47.5		
11.48 (The first swimming motions occurred.)			
12.12 P. M.	57	76	0.75
2.00	47	55	0.85

These experiments, then, so far as they go, indicate that, under conditions of gradual approach toward asphyxia (as when a fish is left in a small volume of unchanged water), there is for a time increasing restlessness attended by a rising rate of respiration and greater frequency of spouting. In the cases closely followed, there were, early in the experiment, alternate periods of rest with slow respiration, and periods of activity with rapid respiration and frequent spouting. This behavior suggests that, as the fish rests normally for a time, it begins to suffer discomfort because of the deterioration of the water. There ensues, then, a brief period of moving about and rapid breathing and spouting. The momentary quickening of the respiration restores comfort and the fish sinks to rest again, soon to repeat the whole performance.

Later in the experiment the rate of respiration was continuously high, with frequent spouting.

At the near approach of asphyxia the rate of respiration gradually diminishes, but spouting continues to occur with greater frequency than under normal resting conditions.

In recovery from asphyxia respiration was at first weak and slow, but during the first few minutes of the period of recovery spouting occurred with very marked frequency,— up to five times in one minute. Within the first hour or two of the period of recovery the rate of respiration gradually rose and attained a maximum far above the normal rate in a resting skate, while the rate of spouting, after the first few minutes of excessive frequency, gradually fell, as the rate of respiration became higher. But so long as respiration continued at a high rate, spouting occurred with much greater frequency than under normal resting conditions.

Spouting Induced by Tactile Stimulation. Some chance observations led me to try the effect of tactile stimulation of the skin in the vicinity of the external spiracular aperture. When the margin of the spiracle was gently touched with the end of a glass rod or with a stiff bit of eel-grass there usually resulted immediately a spouting from both spiracles at once. But a sharper stimulation, or persistent annoyance of one spiracle, often resulted in a vigorous spouting from that spiracle only. When a spouting had once been provoked by tactile stimulation, the immediate repetition of the stimulation usually failed to produce a second spouting. But after an interval of several seconds had elapsed, renewed stimulation usually brought again the spouting response.

One skate was especially lively and responded to stimulation much more promptly and energetically than the others. This animal was experimented with for a brief time in a small tank containing so little water that the external aperture of the spiracle was submerged only about an inch. A fairly vigorous prodding of the skin at the margin of the spiracle by means of the sharp-pointed end of a bit of glass tubing resulted, in some twelve trials, in an extremely energetic spouting from the stimulated spiracle only. This one-sided spouting was provoked first from one spiracle and then from the other, in fairly rapid succession, by rather sharp stimulation of the spiracles alternately. The column of water

was squirted from the spiracle with such energy as to rise through an inch of water and some seven or eight inches vertically upward into the air. Frequently the stimulation was followed, not only by the spouting, but by a sudden dash to another part of the tank, as if to get away from the annoyance.

Tactile stimulation of the skin in the region of the eye also usually caused spouting. A gentle touch upon the outer corneal surface of the eyeball almost invariably provoked a particularly vigorous spouting from the corresponding spiracle. Indeed, stimulation of the cornea was found to be a more certain way of provoking spouting than stimulation of the spiracle itself. The response was always immediate and definite and in nearly every instance unilateral.

I tried also the introduction of solid materials of one sort and another into the gill chambers. I first tried sand, allowing a little to sift into the spiracle when it opened for an inspiration. Sometimes a spouting resulted, but equally often, even though a considerable quantity of sand was introduced, no response whatever followed.

Experimenting in a similar way with another fish, I found in the aquarium some shreds of filmy substance of doubtful nature. They appeared like bits of sloughed-off skin. It well exemplifies the impromptu character of all of these experiments that, making trial of whatever happened to be suggested by the materials at hand, I caused some of this doubtful filmy substance to be sucked into the spiracle at an inspiration. Invariably material of this sort was promptly expelled by spouting. Often one or two inspirations intervened between the one by which the foreign material was drawn in and the spouting by which it was expelled. Usually the spouting occurred from both spiracles at once,— rarely from only the one at which the foreign material was introduced. The material was always ejected by the same spiracle at which it entered.

In the one-sided spouting the action of the unstimulated spiracle appeared to be uninterrupted. The stimulated spiracle simply remained open during one closing of the other.

Summarizing the foregoing account, it appears that the spiracle of the common skate serves chiefly as an in-take for the respiratory

stream, but at somewhat regular intervals the stream is reversed and an expiration takes place via the spiracle, which thereby becomes a spout-hole. With quickened respiration due to exercise, the spouting occurs much more frequently than in the resting fish. Also, when a skate is confined in a small volume of water which is not changed, respiration is quickened and spouting occurs much oftener than under normal resting conditions. Whether in this case the higher rate of respiration is due directly to the condition of the water, or to the activity caused by the unfavorable quality of the water, I am unable to say. M'Kendrick ('79) states that, in the presence of an insufficient supply of oxygen the fish "breathes hurriedly." Finally, spouting occurs with excessive frequency in skates which are just beginning to recover from an advanced stage of asphyxiation. What, in view of these facts, is the probable rôle of the spouting, so far as it is a respiratory act? May it not be roughly analogous to "taking a deep breath"? An occasional reversal of the respiratory stream may serve to clear out the gill chambers, resulting in a more nearly complete change of water in them. The greater frequency of the spouting when respiration is quickened, by whatever cause, and its excessive frequency in recovery from asphyxia indicate, I think, that it has some importance in the way of increasing the efficiency of the respiratory process.

Spouting in response to tactile stimulation in the vicinity of the spiracle indicates that the fish may, under natural conditions, employ the spout-hole as a means of expelling foreign solid materials from the gill chambers, or of dislodging objects from the surface of the body in the region of the spiracles and eyes. The behavior in respect to sand puzzled me at first. Skates when resting on the sea-bottom have a habit of settling themselves into the sand and washing it over their backs in such a way that sand would, apparently, be very likely to sift into the spiracles, and one might suppose that sand would be particularly irritating. But in my experiments the skates were indifferent to the introduction of considerable quantities of sand, while soft filmy materials were promptly spouted out. On further consideration, it occurred to me that sand, being a finely divided substance, would easily wash out through the gill clefts, whereas, being heavy, it could not so

readily be forced up through the spiracles. But the larger fragments of soft material (such as bits of sea-weed) are likely to be caught on the gill-rakers, tending to clog the branchial passages, and could best be dislodged and expelled by a reversal of the currents.

The prompt, vigorous, and almost unfailing response to a touch upon the cornea suggests that the fish regularly employs spouting as a means of keeping the eyes unobstructed. The external opening of the spiracle is so near the eye that a stream spurted from the spiracle would readily wash away foreign objects which settle upon the eye.

Regarding the spiracle as one of a series of visceral clefts which were primitively similar in structural relations and in function, it is evident that, serving as it does such a diversity of uses, it has come to differ from the more posterior visceral clefts quite as markedly in its function as in its structural conditions.

BIBLIOGRAPHY.

BREHM, A. C.

'79. Thierleben. Band 8, Die Fische. Leipzig. xvi + 426 pp., 11 Taf., 145 Textfig.

DAHLGREN, U.

'99. The Maxillary and Mandibular Breathing Valves of Teleost Fishes. Zool. Bull., Vol. 2, pp. 117–124, 3 figs. in text.

DUMÉRIL, A.

'65–70. Histoire Naturelle des Poissons. Paris. Tome 1, 720 pp., Tome 2, 624 pp.; 26 pl.

GARMAN, S. W.

'74. On the Skates (Rajæ) of the Eastern Coast of the United States. Proc. Boston Soc. Nat. Hist., vol. 17, pp. 170–181, 1 fig. in text.

M'KENDRICK, J. G.

'79. On the Respiratory Movements of Fishes. Journ. Anat. and Physiol., Vol. 14, pp. 461–466, pl. 28.

A CRITICAL AND STATISTICAL STUDY OF THE DETERMINATION OF SEX, PARTICULARLY IN HUMAN OFFSPRING.[1]

F. H. PIKE.

I. Introduction.

Cuénot ('99) and Strasburger (:00) summarized the evidence in favor of the heredity of sex in animals and plants, respectively. Rauber (:00) in the same year as Strasburger, declared for the heredity of sex in man.

Bateson in 1902 suggested that the Mendelian law might apply to the heredity of sex. Castle (:03), accepting Cuénot's and Strasburger's views without question, formulated an hypothesis to account for the heredity of sex in accordance with Mendel's law. Weldon (:01) had already shown that Mendel's original results with cotyledon color in peas differed from the theoretical numbers by something less than the limits of error. At the time Castle's theory appeared, it occurred to me to gather statistics of births in order to determine in a similar way the probability that the actual numbers of male and female births would be the numbers demanded by the hypothesis.

II. Review of Previous Work.

The idea that the sex of the offspring could be influenced by changing the environment of the parents or of the very young embryo has long been current. Yung's ('83) experiments on tadpoles, in which he was apparently able to control the sex by

[1] This study was begun under the direction of Professor C. H. Eigenmann of the Department of Zoology of Indiana University and was completed in the Hull Physiological Laboratory of the University of Chicago. The author desires to express his obligations to the health officers and registrars who have supplied him with statistics; to his colleagues in the Hull Laboratory for criticism of the manuscript; and to Professor Eigenmann for encouragement and assistance.

changing the nutrition, have been cited as a demonstration of this point. Statistics of human births have been judged in such a way as to lend some support to this view. A good review of this aspect of the question has been given by Geddes and Thompson (:01). The validity of such conclusions has been well discussed by Newcomb (:04), who has made a statistical inquiry into the probable causes of sex in the human subject. Newcomb concludes that the causes of sex are beyond voluntary control.

Cuénot repeated Yung's experiments on tadpoles with contrary results. Eggs from the same mother, but of different layings, gave a more constant proportion of males to females than Yung obtained. The ratio of males to females in the young (54.85% females) did not differ materially from the ratio (61.5% females) existing among the metamorphosed tadpoles found in a state of nature in the vicinity of Nancy. Born ('81) found 52 per cent of females in the metamorphosed tadpoles near Breslau. Griesheim ('81) found 63.63 per cent of females in young *Rana temporaria* in the vicinity of Bonn. Pflüger ('81) found 64.5 per cent of females in the same vicinity, and 86.8 per cent near Utrecht. The percentage of old females in the latter vicinity he found to be 51.2. Pflüger concluded that the sex was determined in the egg. From his results on tadpoles and other animals, Cuénot likewise concluded that sex was not influenced by the conditions of development. He decided further that there was a certain sexual ratio common to the frogs of any particular vicinity, and that this ratio might vary among frogs of different localities. In view of the comparatively small number of frogs observed, the last conclusion may possibly be open to question.

Von Malsen (:06) and Issakowitsch (:06), the former for the worm *Dinophilis apatris* and the latter for Daphnia, have recently reaffirmed the statement that an abundance of food and a low temperature cause a greater number of eggs to develop into females, while a higher temperature and a scarcity of food result in the development of a greater number of males. The food supply, according to them, is the main factor in this process, and the temperature acts only indirectly by influencing the nutrition. It is to be remembered, however, that in experiments dealing with a whole animal, it is difficult to exclude all causes except food and temperature.

Strasburger (:00) made many experiments with diœcious plants, growing them on various kinds of soil and under various conditions, in the attempt to modify the sexual ratio. The following results with *Melandrium album* may be cited as an example:

TABLE I.

Kind of soil	*Males*	*Females*	*Females to 100 males.*
Fertilized garden soil	410	562	137.0
Unfertilized garden soil	235	282	120.0
Fertilized field soil	384	479	124.4
Unfertilized field soil	254	307	120.8
Sand	321	411	128.0
Totals	1604	2041	Mean 127.2

Thus sexual ratios for groups of plants grown under the most diverse nutritive conditions did not differ greatly from the mean. Strasburger concluded that an arbitrary determination of sex in dioecious phanerogams has never been accomplished, and he is inclined to apply this conclusion to all plants.

Rauber (:00) studied statistically the distribution of sex in man. He found everywhere an excess of male births, but this early excess in the young was changed, because of the greater mortality of the males,[1] to an excess of females in later life, and particularly in old age. He showed that the sexual ratio for Europe was 1000 female to 1060 male births, and that this mean ratio was fairly constant in the different parts of Europe. Reasoning on the basis that, if sex was determined by environment, the great diversity of external conditions in the different parts of Europe should cause a considerable difference in the sexual ratios for the different countries, he concluded that sex is hereditary in man.

According to Rauber, there is normally an excess of female births in horses, sheep and certain other domestic animals.

Punnett (:04a) has made a statistical study of the distribution

[1] The relative death rates per million infants of each sex, as determined from Tatham's English Life Tables is 161,036 males and 131,126 females during the first year after birth. The excess of male deaths is 29,910 per million infants of each sex, or approximately 1.57%. (Cited by Punnett, :04a, p. 265).

of male and female births in London, in order to determine whether or not the sexual ratio is affected by the nutrition of the parents. For this purpose he divides London society into three groups, following Rowntree's (:02) division of the society of York. These groups are (1) the servant keeping class, (2) the artisan class in which the family earnings are in excess of 26 shillings a week, and (3) the laboring class in which the family earnings fall below 26 shillings a week. Rowntree found that, compared with a standard dietary containing 125 grams of proteid and possessing a total energy content of 3500 calories, the first group has a dietary containing more food than is necessary for the maintenance of health; that the second class has, in general, a sufficient diet, although the family must practice strict economy in order to procure it; the third class is, as a rule, seriously underfed, the average deficiency in proteids amounting to as much as 29 per cent. Assuming that these considerations apply to London as well as to York, Punnett finds that there is either no effect upon the sexual ratio which can be attributed to parental nutrition, or, at most only a very small effect. He finds also that the statement of Düsing as to the greater proportion of males among the first born children is supported by the statistics of the English lying-in hospitals. Furthermore, mothers whose first birth occurs between the ages of nineteen and twenty-three years bear a larger proportion of males at this birth than mothers whose first birth occurs either earlier or later in life.

III. STATISTICAL DATA.

On the fundamental errors in the statistics.— Rauber (:00) has considered the errors in even the best statistics, and only a brief discussion of them will be given here. In order to compute the exact sexual ratio, it is necessary to obtain statistics of all births, both premature and full term, living or still born. The effect upon the sexual ratio of disregarding the premature and still births will be pointed out below. For purposes of heredity, homologous or duplicate twins, developed from a single ovum, and invariably of the same sex, should be counted as a single birth. The author has at hand no sufficient data upon which to base an idea of the magnitude of the error which might be intro-

duced by counting such twins as two births. Of the eighteen cases of twins and triplets considered by Wilder (:04), twelve pairs of duplicate twins were females. If such a large proportion of all duplicate twins should be females, the error introduced would be considerable, and the preponderance of male births increased. The number of cases given, however, is too small to warrant drawing conclusions as to the relative frequency of male and female duplicate twins.

The sexual ratio.— The sexual ratios for eleven European countries, as they existed sometime during the latter part of the nineteenth century, have been taken from the twenty-eighth annual report of the Massachusetts State Board of Health through the courtesy of the late Dr. Samuel W. Abbott. The figure for England from 1628 to 1642 is that given by Lexis ('92). The ratio for the United States was computed from 2,021,955 births — 1,038,432 males and 983,523 females — the statistics for which were furnished by the health officers of the various states having reliable statistics of births.

TABLE II.

Nation	*Number of males to 1000 females*
German Empire (1871–1880)	1062
Switzerland	1063
Austria	1067
Italy	1071
France	1063
Belgium	1058
Holland	1063
Denmark	1058
England (modern times. Living births only)	1038
England (1628–1642)	1068
Sweden	1060
Norway	1061
Massachusetts (1876–1896) still births included	1066
Massachusetts (1856–1875) living births only	1055
United States	1056
Mean of all ratios	1060

A considerable increase in the sexual ratio occurs when still births are included. The sexual ratio for the city of Chicago, based upon all births reported in the years 1898 to 1902 inclusive, (141,233), is 1065. During this period 4828 males and 3554 females were prematurely or still-born. If these premature and still-births are deducted from the total number reported, the number of males to 1000 females is 1035. It becomes necessary, then, to decide whether or not still-births shall be counted. Still-births must be reported under penalty. Since the living children are the ones voluntarily reported, their record is not complete; but we may suppose that the parents are as apt to report a birth of one sex as of the other. The statistics of living births, therefore, in localities where birth registration is not compulsory, probably approach more nearly to the true ratio than the ratio based upon both still- and living births. If birth registration is compulsory, the ratio should be computed on a basis of all births reported. The ratio for Chicago computed on the basis of living births only is very nearly the same as the ratio for England. The ratio for Massachusetts, computed from living births only, is less than that based upon both living and still births. It is probable, therefore, that the incompleteness of the statistics is the most serious source of error.

The constancy of the sexual ratio.—An examination of the statistics shows a remarkable constancy of the sexual ratio in all parts of Europe and in the United States, for a period ranging from 1856 in Massachusetts, through 1871–1880 in the German Empire, to the year 1902 in Chicago. During these years and in the various countries, there were periods of war and peace, of famine and plenty, beside a great variety of racial and climatic conditions. Yet the greatest variation from the mean, exclusive of England, is only eleven in 1000 — a difference of one per cent.

In the same country for a period of years, the ratio is approximately constant. As an example, we may take the statistics for England (Table III) during the twelve years from 1888 to 1899, inclusive.

Table III.

(Taken from Sessional Papers of the House of Lords)

Year	*Total Births*	*Males*	*Females*	*Males to 1000 Females*
1899	928646	473172	455474	1039
1898	923265	468920	454345	1032
1897	921693	469180	452513	1037
1896	915331	465660	449671	1035
1895	922291	468886	453405	1034
1894	890289	453016	437273	1036
1893	914572	465711	448861	1037
1892	897957	456622	441335	1034–5
1891	914157	465660	448497	1038
1890	869937	442070	427867	1033
1889	879868	447172	423696	1033
1888	885944	451218	434726	1037
	10,864,950	5,527,287	5,336,663	1036

It will be seen that the ratio for any one year does not differ by more than four in one thousand from the mean calculated from more than ten million births. As a further example, the sexual ratio in Massachusetts, based upon living births only, for the years 1856 to 1875 inclusive is 1059. The ratio for the years 1876 to 1896 inclusive, based upon a considerably greater number of births, is 1053. The mean for the two periods is 1055. The sexual ratio for the period in which the Civil War occurred differed by approximately one half of one per cent from the later period of peace, and by less than one half of one per cent from the mean of the two periods. If external conditions exerted any effect upon the parents in such a way as to change the sex of the offspring, the change due to such influences was not greater than one in two hundred.

Social, political and material conditions in England during the years 1628 to 1642 were vastly different from those during the years 1888 to 1899, but the difference between the sexual ratios for the two periods — 1068 to 1000, and 1036 to 1000 respectively — is not greater than the difference between the ratios for the city

of Chicago computed upon the living births only for a given period, and upon all births for the same period. It does not, therefore, appear necessary to assume with Strasburger that the sexual ratio for England has changed to any considerable extent in two hundred years.

The effect of a war upon the sexual ratio.— It has long been a current belief that more males were born in a period following a war than in a similar period of peace. Newcomb considers this statement unworthy of serious consideration. It may be said that, so far as the United States is concerned, such statements are based upon an insufficient number of births, and that the statistics are for the most part worthless. I have many letters from state health officers to the effect that there are now no reliable statistics of births in their respective states.

The sexual ratio independent of external conditions.— In view of the remarkable constancy of the sexual ratio under diverse social, political and material conditions and for long periods of time in different races, it seems incredible that the determination of sex should be dependent upon external conditions.

If the sex of the offspring is independent of external conditions, what is the determining factor? Two general explanations are open. There is first the possibility that sex is determined by a series of accidents, as Newcomb suggests, and second, the possibility that sex is hereditary.

The possibility that sex is determined by a series of accidents.— Newcomb likens the sex of a child to a particle floating on a stream of water. In the early part of its course the stream is single, but an obstacle divides it into two at the lower part. A particle entering the stream at the upper part may pass on either side of the obstacle, the exact course depending upon a multitude of accidental causes up to a certain point, after which its course on one side of the barrier or the other is fixed. So with an ovum. In its early development, there is the possibility of developing into either a male or a female, the sex depending upon a series of accidents.

Newcomb showed from statistics that the probability that twins will be of the same sex is .77, and the probability that they will be of opposite sexes is .23. It is impossible to tell from Newcomb's

tables whether duplicate twins were excluded, as they should have been, since but one ovum is involved. If duplicate twins had been excluded, the probability that ordinary twins would be of the same sex might have been even less than .77; for duplicate twins are invariably of the same sex.

Sex determined before the first cleavage of the ovum.— Let us now examine into the bearing of these considerations upon Newcomb's hypothesis. To continue his simile, two particles starting together will have a greater chance of remaining together and passing on the same side of the barrier than two particles somewhat removed from each other. Similarly, two ova developing together (in the same environment) will have a greater chance of producing offspring of the same sex than two ova developing at different times, but neither the two particles nor the two ova invariably follow the same course. If any series of accidents acting upon the ovum after fertilization is to determine the sex of the twins, it is incredible that it should always produce the same result in both. Since, however, duplicate twins are always of the same sex, this view becomes untenable, and we must limit the action of a series of accidents to the period preceding and possibly including fertilization. The conclusion that at or immediately after fertilization, the sex of the offspring is determined once for all seems inevitable. The effect upon the ovum of any series of accidents must cease before the first cleavage is accomplished.

Is sex determined by either parent alone?— Having concluded that the sex of the offspring is determined at or before the time of fertilization, we may inquire further whether the sex of the offspring may not be determined by the ovum alone, or by the spermatozoon alone. First, the ovum may have the potentiality of developing into either a male or a female embryo. During maturation the chromatic material necessary for the development of an embryo of one sex is cast off in the polar bodies, and that necessary for an embryo of the other sex is retained. The spermatozoon thus plays a purely asexual rôle. This hypothesis postulates a qualitative reduction of the chromatin in maturation. According to another variety of this hypothesis the ovum assumes the asexual rôle, and the sex of the embryo is determined solely by the spermatozoon. Since all spermatozoa do not produce

embryos of the same sex, there must have been, at some period in the development of the spermatozoon, a qualitative reduction of the chromosomes, those necessary for a male going into one spermatozoon, and those necessary for a female into another. If we accept this hypothesis, we must show why a constant and unequal proportion of all ova or of all spermatozoa have chromosomes, *e. g.* the accessory chromosome, which will produce an embryo of a certain sex. As an alternative hypothesis we may suppose that both ovum and spermatozoon play a sexual rôle, and that the sex of the embryo, in common with other characteristics, is determined by both sexual elements. This view, as I shall show subsequently, is the more probable.

If we cannot explain the cause of sex by postulating a series of accidents of unknown nature occurring after fertilization, can we explain it on the second possibility,—heredity? And if so, which of the two great laws of heredity are applicable to the case? The first question I shall answer in the affirmative, and proceed to the discussion of the second.

The application of Mendel's law.—On the basis of Mendel's law we must suppose that each ovum has equal chances of developing into a male or into a female embryo. Given two thousand ova, chosen at random, the chances are even that a thousand of them will develop into males and one thousand into females. We might reasonably expect also that in some groups we would find an excess of males, and in others an excess of females, but the mean of all groups would be 1000 each of males and females.

Punnett (:04b) in order to test Bateson's suggestion, attempted an enumeration of the sexes in *Carcinus mænas*. He found an excess of females in groups of individuals of the same size, but this excess decreased in groups of younger individuals and there were indications of an approximately equal distribution of the sexes at the time of hatching. The exact proportion of the sexes at the time of hatching could not, however, be determined.

McIntosh ('04,) from a study of the Norway lobster, concluded that the young were hatched in about equal proportions of the sexes, but was not able to determine the exact proportion.

Taking the English statistics given in Table III as a basis, we may compute the probability that the actual distribution of males

and females would be obtained by such a random choice. Instead of the theoretical distribution of 1000 males and 1000 females, the actual numbers of males and females in 2000 births are 1017.6 and 982.4 respectively, or, for convenience in calculation, 1018 males and 982 females. The probability that, in choosing at random, we should obtain such a distribution is $.60984 \times 10^{-920}$. The probability that in eleven such choices, we would always obtain the same distribution is infinitesimal. The probability that, in every case where the births are numerous enough to be representative of the actual conditions, we should always obtain practically the same distribution is practically zero. There is about the same probability that Mendel's law holds for all these cases.

A single concrete example taken from organic chemistry will serve to emphasize this point and perhaps to make this mathematical abstraction clearer. In the transformation of acetaldehyde to lactic acid by the addition of hydrocyanic acid, saponification and oxidation, each of two isomeric forms of lactic acid is, on the theory of probability, equally likely to be produced. The two forms differ in optical activity, one being dextro-rotatory and the other laevo-rotatory. Experimentally, it is found that the two forms are actually produced in exactly equal amounts, and the mixture of the two is optically inactive. A variation of from three to seven per cent from the theoretical yield would be fatal to the theory of probability. In general, in the synthesis of organic bodies in which two isomeric forms are possible and theoretically equally probable, the experimental results agree much more closely with the theory than do the statistical results of human births.

Neither ovum nor spermatozoon play asexual roles.— It is evident that these considerations apply also to the hypothesis that either the ovum or the spermatozoon play a purely asexual rôle. If we suppose that, in the qualitative reduction of the chromosomes, male and female chromosomes are equally likely to be extruded in the polar bodies, there is practically no probability at all that we would obtain the actual distribution of males and females. If the hypothesis is correct, there must be some definite regulative mechanism of unknown nature which determines the extrusion of the chromosomes. It is incumbent upon those

who maintain the truth of such a hypothesis to explain the nature of this unknown mechanism.

In the case of the accessory chromosome (McClung, :02), the statement is made that it occurs in one half of the spermatozoa of Orthoptera and Hemiptera. If we are to suppose that the accessory chromosome acts as a sex determinant, and that sex characters are to be treated as if they were Mendelian alternates (Wilson, '07), we should find a sexual ratio equal to unity or differing from unity by an extremely small per cent. We cannot, however, account for the determination of sex in the human subject on any basis of an equal division of spermatozoa into male and female producing sperms, unless we suppose, as Wilson concedes for the sake of argument, that sex may be modified by external conditions. The statistical evidence is strongly against this alternative. If it can be shown that the accessory chromosome occurs in the spermatozoa of a species in the same proportion as the sex to which it gives rise occurs in the young of that species, the statistical evidence in its favor will be increased. At present, there is no such evidence in its favor, as we do not know the exact sexual ratio of the species in which the accessory chromosome has been observed.

The strongest evidence known to the author in favor of the Mendelian theory of dominance in the determination of sex is that cited by Harper (:07) in regard to plants. That the stamens should develop and the pistil be suppressed in the fungus-infected female plants of the campion is strongly suggestive of the recessiveness of the stamens under ordinary conditions.

The application of Galton's law.— To explain the remarkable constancy of the sexual ratio by Galton's law, we have only to assume that sex, in common with other physical characteristics, is inherited equally from the paternal and maternal ancestry; and to explain the preponderance of males in the present generation, we assume that in this ancestry for five or six generations back, there has been a preponderance of males. In this we are justified since there is direct statistical evidence that, for more than two hundred years, there has been an excess of male births in England. Accepting the statistics as being reasonably accurate, the accordance with Galton's law of ancestral inheritance is much closer than with Mendel's law.

IV. The Biological Significance of the Sexual Ratio.

Rauber, apparently taking the view that an excess of females is the normal condition, explains the present preponderance of male births in man by supposing that those tribes or families which, in primitive times, had the greatest proportion of males would possess a certain advantage in warfare and thus be enabled to overpower those in which there was a larger proportion of females. The male preponderance, once established, would be perpetuated by heredity. This ingenious explanation, does not, however, account for the excess of females among the domestic animals. What the sexual ratio was in primitive man we have no means of knowing. Neither do we know what the sexual ratio was in horses and sheep before they were domesticated. One would expect that the sexual ratio in wild animals would depend somewhat upon the mating and breeding habits of a species. In those species of birds, in which one male mates with one female for a season or for life, we might expect that the sexual ratio would be nearly unity, the excess of one sex or the other depending on which one was exposed to the greater dangers and had the less chance of growing to maturity. In herds of wild horses, cattle and bison, there are many females to one male. All but the strongest males are killed off by the others and the number of adult males is thus kept down to the needs of the herd. Those individuals which are most likely to produce males are not always the ones likely to reproduce. In the dairy industry, females are of more value than males, and it is possible, in fact more than probable, that man has unconsciously, by selection in breeding, increased the proportion of female births.

No one sexual ratio may be taken as the standard.— If sex is hereditary, we might reasonably expect that the relative numbers of male and female births in any species would be those which, after deducting the early deaths, would confer upon the species at the period of sexual maturity of its individuals the greatest advantage in the struggle for existence so far as the production of young is concerned. This would mean that the species would enjoy the maximum reproductive power, and this condition would be fulfilled when there were no superfluous, sexually mature males or females.

Let us suppose that a species possesses the maximum reproductive power when there are x males to n females, the relative magnitudes of x and n depending upon the breeding habits of the species. Let us suppose also that a males and b females die before reaching sexual maturity. The number of males born will therefore be $a + x$, and the number of females $b + n$. The sexual ratio will be $\frac{a+x}{b+n}$, or $\frac{a+x}{b+n} \times 1000$ if we wish to express the number of male births to 1000 female births.

In a monogamous species, such as the American robin, the reproductive power of the species would be at a maximum when there were equal numbers of sexually mature males and females. If the males are more likely to be killed off than the females, a would be greater than b, and the sexual ratio would be greater than unity. Surplus males or females would die off without reproducing. In a polygamous species, such as the ox, it is not necessary that there be equal numbers of sexually mature males and females to give the species its maximum reproductive power, and $a + x$ might well be less than $b + n$. The sexual ratio would in this instance be less than unity. The relative proportions of the sexes in any species may, therefore, be looked upon as one of the physiological adaptations of the species, determined by the conditions of its existence.

V. THE EXPERIMENTAL POINT OF ATTACK.

If sex is inherited according to Galton's law it should be possible, by suitable selection of the parents, to establish a strain of animals or plants in which males or females occur with any desired degree of frequency compatible with perpetuation of the species. The practical benefits of the favorable results of such an experiment to the dairy and grazing interests of the country would be difficult to estimate. Castle has recently published some experiments on the effects of inbreeding, cross-breeding, and selection upon the fertility of flies (Drosophila) in which he found no marked change in the sexual ratio. Other experiments are now in progress.

There is, however, a second point of attack which is more distinctly within the province of the physiologist. As previously pointed out, it is difficult to imagine why ordinary twins should

often be of different sexes while duplicate twins are invariably of the same sex if nutritive or any other conditions outside of the ovum itself are responsible for the sex of the offspring. It is perhaps conceivable that, in the case of ordinary twins, the placental circulation may be more highly developed, and the nutrition consequently better, for one twin than for the other, or that some peculiar local characteristic of the uterine wall may affect one twin more than the other. The probability of any such dissimilarity of conditions in the case of duplicate twins, where the same placenta supplies both with nutriment, and any local peculiarity of the uterine wall affects them equally, is very small. It must therefore be admitted that ordinary twins may be subjected to more diverse conditions during development than duplicate twins, and it is conceivable that the latter might sometimes be of opposite sexes if we could vary the conditions during development. This would manifestly be a matter of great difficulty in mammals, but a simpler method of attack is open.

Roux ('85) and others have shown that the individual blastomeres of a frog's egg will, when separated from the others, develop into complete embryos. Such embryos are presumably comparable in all respects to duplicate twins, and if by any means we might cause two blastomeres from the same ovum of any animal normally reproducing sexually to develop into embryos of opposite sexes, we would have a demonstration that sex was not determined at the time of fertilization of the egg. Failure to produce from the same egg two embryos of opposite sex would be evidence that we have, at present, no known means of changing the sex of the embryo after fertilization of the egg. It is incumbent upon those who maintain that sex is determined by the environment to show that two embryos of opposite sexes can be produced from the same ovum. The experimental solution of the problem of the causes which influence the sex of the offspring, as well as the significance of sex itself, is to be sought in the simple cell whose environment can be varied in a known way and to a known extent. It is obvious, also, that the problem of sex determination is but a particular phase of the much wider problem of the extent to which the ovum may be modified by a change in the external environment. Furthermore, if we acquire experimental data on the deter-

mination of sex, we will at the same time acquire experimental data on the question of a period of sexual indifference in the development of the individual. If sex is determined, as appears probable from the statistical data, at the time of fertilization, it is difficult to conceive of a period of real sexual indifference in the history of the individual. But if we can influence the sex of an individual after fertilization of the ovum, we will at the same time demonstrate a period of sexual indifference in development.

The bearing of artificial parthenogenesis on the problem of sex. — In a personal communication to the writer, Dr. Woelfel has suggested that if, by any means other than fertilization by a spermatozoon, we are able to cause an ovum of an animal which normally reproduces bisexually to develop to sexual maturity, we will have a demonstration that one parent plays a purely asexual rôle in the production of sex. This conclusion, however, does not follow necessarily. Moreover no individual arising by artificial parthenogenesis has as yet grown to sexual maturity. Whether this failure of normal development is due to improper nutrition of the young or to a lack of some essential detail in fertilization cannot, perhaps, be stated at present. One is inclined to regard the production of a sexually mature individual, which may in its turn reproduce, and the transmission of certain hereditary characteristics to the offspring as two essential details of fertilization. Until these phenomena have been imitated by artificial means, one is loath to believe that normal fertilization is imitated in all essential details by artificial parthenogenesis (Loeb :06). The study to artificial parthenogenesis may have an important bearing upon the determination of sex, but the true significance of the work already done is not apparent.

VI. SUMMARY AND CONCLUSIONS.

The statistical study of the distribution of sex in man shows that there is a slight but constant excess of male births. The greater mortality of the males leads to a preponderance of females in old age.

There are certain unavoidable errors in the statistics, the two most serious being (1) incompleteness, and (2) disregard of dupli-

cate twins. It is not probable, however, that these errors are in such a direction as would change the sexual proportion if we could get absolutely correct statistics.

The sexual ratio is remarkably constant in widely different localities and at widely different times; in a given locality the ratio is not altered by the varying social and material conditions of the parents, as indicated by statistics.

The study of duplicate twins shows that if sex is determined by a series of accidental causes, such causes cannot be operative after the fertilization and first segmentation of the ovum.

The logical conclusion from the statistical data is that sex is hereditary. Mendel's law does not apply. The constancy of the sexual ratio for more than two hundred years may best be explained by supposing that sex follows Galton's law of ancestral inheritance.

If sex is hereditary, we may explain the significance of the sexual ratio on the basis of natural selection by supposing that the proportion of the sexes in any species is such as will give that species the maximum reproductive power at the time of sexual maturity of its individual members. The sexual ratio may be expected to vary for different species, depending upon the mating and breeding habits of any particular species. The sexual proportion may be considered as one of the physiological adaptations of a species.

The conclusions drawn from statistical data should be tested experimentally. There are two experimental points of attack: (1) Breeding experiments to determine whether the sexual proportion can be altered by selection. (2) Experiments on the separate blastomeres from one ovum to determine whether two embryos of different sexes can be reared from the same egg, and whether there is a period of sexual indifference in the development of an individual.

HULL PHYSIOLOGICAL LABORATORY
CHICAGO

BIBLIOGRAPHY.

Only a partial bibliography is given here. Cuénot and Düsing ('84) give all the literature for animals up to 1899. Strasburger and Gregory give the botanical literature. A less complete review is given by Loeb (:06).

BATESON, W. and SAUNDERS, E. R.

:02. Experimental studies in the physiology of heredity. Reports to the Evolution Committee, No. 1, London.

BORN, G.

'81. Experimentelle Untersuchungen über die Entstehung der Geschlechtsunterschiede. Breslauer ärtzliche Zeitschrift, 3, p. 25.

CASTLE, W. E.

:03. The Heredity of Sex. Bull. Mus. Comp. Zool., 40, pp. 189–218.

CASTLE, W. E., CARPENTER, F. W., CLARK, A. H., MAST, S. O., and BARROWS, W. M.

:06. The effects of Inbreeding, Cross-breeding and Selection upon the Fertility and Variability of Drosophila. Proc. Amer. Acad. Arts and Sciences, 41, pp. 729–786.

CUÉNOT, L.

'99. Sur la determination du sexe chez les animaux. Bull. scientif. de la France et de la Belgique, 32, pp. 462–535.

DÜSING, C.

'84. Die Regulierung des Geschlechtsverhältnisses bei der Vermehrung der Menschen, Thieren und Pflanzen. Jenaische Zeitsch. f. Naturwissenschaft. 17, p. 593.

DÜSING, C.

'85. Der Experimentelle Prüfung der Theorie von der Regulierung der Geschlechtsverhältnisses. Idem, 19, supp. Heft 2, p. 108.

GEDDES, PATRICK, and THOMPSON, J. ARTHUR.

:01. The Evolution of Sex, Chapter IV, 2d. ed. London.

GREGORY, R. P.

:04. Some observations on the determination of sex in plants. Proc. Cambridge Phil. Soc., 12, pp. 430–440.

GRIESHEIM, A.

'81. Ueber die Zahlenverhältnisse der Geschlechter bei Rana fusca. Arch. f. d. ges. Physiol., 26, p. 237.

HARPER, R. V.

:07. Sex Determining Factors in Plants. Science, N. S. 25, pp. 379–382.

ISSAKOWITSCH, A.

:06. Geschlechtsbestimmende Ursachen bei den Daphniden. Arch. f. mikr. Anat., 69, p. 223.

LEXIS.
'92. Geschlechtsverhältniss der Geborenen und der Gestorbenen. Handwörterbuch der Staatswissenschaften, 3, p. 816: new edition 1900, 4, p. 177, cited by Strasburger (:00).

LOEB, J.
:06. The dynamics of living matter. N. Y. and London. Chapters IX and X.

MCCLUNG, C. E.
:02. The accessory chromosome — sex determinant? Biol. Bull. 3, pp. 43–84.

VON MALSEN, H.
:06. Geschlechtsbestimmende Einflüsse und Eibildung bei Dinophilus apatris. Arch. f. mikr. Anat. 69, p. 63.

MCINTOSH, D. C.
:04. On the variation in the number and arrangement of the male genital apertures and on the proportion of the sexes in the Norway lobster. Proc. Cambridge Philos. Soc., 12, pp. 441–444.

NEWCOMB, S.
:04. A Statistical Inquiry into the Probability of Causes of Sex in Human Offspring. Carnegie Institution, Publication No. 11, pp. 1–34.

PFLÜGER, E.
'81. Einige Beobachtungen zur Frage über die das geschlechtsbestimmenden Ursachen. Arch. f. d. ges. Physiol. 26, p. 243.
'82a. Hat die Concentration des Samens einer Einfluss auf das Geschlecht? Idem, 29, p. 1. (Has no effect.)
'82b. Ueber die das geschlechtsbestimmende Ursachen und die geschlechtsverhältnisse der Frosche. Idem, 29, p. 13.

PUNNETT, R. C.
:04a. On nutrition and sex determination in man. Proc. Cambridge Phil. Soc., 12, pp. 262–276.
:04b. Note on the proportion of the sexes in Carcinus mænas, Idem, pp. 293–296.

RAUBER, A.
:00. Der Ueberschuss an Knabengeburten und seine biologische Bedeutung. Leipzig. (Abstract by R. F. Fruchs in Biol. Centralbl., 21, p. 833, 1901).

ROWNTREE, B. S.
:02. Poverty, a study of town life. Second edition.

ROUX, W.
'85. Ueber die Bestimmung der Hauptrichtungen des Frosch-embryos im Ei, und über die erste Teilung des Froscheies. Breslauer ärtzliche Zeitsch. [The literature is given by Wilson (1900)].

STRASBURGER, E.
:00. Versuche mit diöcischen Pflanzen in Rücksicht auf Geschlechts-

verteilung; Biol. Centralbl., 20, pp. 657–65, 689–98, 721–31, 753–85.

WELDON, W. F. R.

:01–:02. Mendel's Laws of Alternative Inheritance in Peas. Biometrika, 1, pp. 228–254.

WILDER, H. H.

:04. Duplicate Twins and Double Monsters. Amer. Journ. of Anat., 3, p. 387.

WILSON, E. B.

:00. The Cell in Development and Inheritance. 2nd ed. New York, p. 408 et seq.

:07. Sex determination in relation to fertilization and parthenogenesis. Science, N. S. 25, pp. 376–379.

YUNG, EMILE.

'83. Contributions à l'histoire de l'influence des milieu physico-chimiques sur les êtres vivants. Arch. de Zool. experimental, 2e serie, 1, p. 31.

'85. Influence des variations du milieu physico-chimiques sur le développement des animaux. Arch. des Sciences Phys. et Naturelles, 14, p. 502.

CHUBS' NESTS

ALFRED W. G. WILSON

During late summer, at times of low water on almost any one of the numerous small streams tributary to the Upper Ottawa River, the passing voyageur cannot fail in having his attention drawn to curious conical piles of coarse gravel and pebbles which occur along the river shores. Locally these piles of stones are called "Chubs' Nests." The following notes are published in the hope that they may prove of interest to American Naturalists.

The accompanying plates will give a general idea of the shape and character of these heaps of stones. They are conical in form, with a circular or oval base. The volume of the gravel of which they are built will vary from a good sized wheelbarrow load to about a cart load. The individual pebbles vary in size; the great majority would readily pass through a two inch ring. In a few cases oblong pieces of schist about three inches in length were noted but their cross section would not be more than one square inch. The largest pebbles used in the construction of the heaps would weigh at least half a pound each; most of the pebbles would weigh less than four ounces each. The rock material from which the pebbles have been derived is often quite different from the rock of the immediate vicinity, showing that the pebbles have been transported some distance to their present resting place. In a number of instances it was found that the interior of the heap consists almost entirely of small pebbles less than an inch in the maximum dimension, the larger ones forming only an outer layer over the whole cone.

The dimensions of two of these heaps of stones were as follows: — No. 1. Base, length 6.5 feet, width 5 feet at one end (left of figure 1), and 4 feet at the other, height 21 inches, angular slope of the side of the cone about 48° to the vertical. This pile was built of mixed pebbles, chiefly granite and schist. (See figure 1.)

No. 2. Base, nearly circular and four feet in diameter, height 22 inches, angular slope 49° 45′. (See figure 2.)

In a very large number of cases examined the stones were found to be piled quite loosely so that the slightest jar set them sliding down into a position of more stable equlibrium.

Along the larger streams and rivers the heaps are usually found in small bays off the main stream or on bars and ridges on the sides of the main channel, in quiet but never in dead water. In some places near the watersheds they occur in midstream, and occasionally they are sufficiently numerous to hinder and partly obstruct canoe navigation, where the water is shallow and the stream narrow.

FIG. 1.

In the early spring when the waters are high and usually more or less turbid the cones are not in sight; but as the waters recede the apices of the cones gradually appear above the surface and late in the season the water may have receded so that the whole cone together with the bar on which it was built comes into view. The tops of the "nests" shown in figures 2 and 3 were fully five feet above the surface of the water when the pictures were taken in August. In early June the water was probably six feet higher and the tops would have been under at least a foot of water.

As to the origin of these curious heaps of pebbles, the Indians

and Bushmen all attribute them to small fish — called *Chub* by the whites and *Awadosi* (stone carriers) by the Indians.[1] Personally I have made numerous inquiries but I have not been able to find any one who will say he has actually seen the fish at work, still they all insist that it is the fish who make them. A careful examination of over one hundred heaps, scattered along a line of gravel more than three hundred miles in length has convinced the writer that the cones are of animal origin, that the materials have been assembled by some intelligent agent, not by stream action.

FIG. 2.

These heaps of stones are said to be built in the early spring and are presumably used for spawning purposes. They are always in places where the water is smooth but still flowing. Except in the very beds of the rivers of this north country, pebble and gravel beds and bars are not found. The shores of the streams are almost universally clay. At high water the rivers expand and invade the woods so that, as one of my canoemen expressed it "The pike go into the bush to hunt." In midstream the water is usually flowing very swiftly at high water and along

[1] Bell. Robert. Recent Explorations to the South of Hudson Bay. *The Geographical Journal*, July, 1897, p. 16.

the shores the ground is covered with logs and bushes. Ground suitable for spawning covered by a moderate depth of water is rare. In nearly every case where the nests were seen the bottom consisted either of large boulders and cobbles, or of soft materials and sand with a certain admixture of partly decayed logs and lower types of plant life, chiefly algæ. On this bottom the conical heaps of stones were built up. It seems not unnatural to suppose that they serve the dual purpose of offering a clean gravel surface for the deposition of the eggs, and at the same time raise these eggs nearer the surface of the water and thus into a zone of more

Fig. 3.

light and warmth than if they were deposited directly upon the bottom.

The fish which are said to be the architects of these curious nests vary in size up to about 18 inches in length, and in weight up to about two pounds or a little over. Their ventral aspect is white, the dorsal dark gray-black, and the broad sides are silver white. The cycloid scales are large and thick, and the body is about three times as deep as wide. The third plate shows a specimen about 14 inches in length which was captured and laid upon the nest before making the picture. President David S. Jordan to whom these data have been submitted considers that

the fish is "probably the Silver Chub or Fall Fish, *Semnotilus corporalis* Mitchell." It may be interesting to sportsmen to know that the fish rise readily to the fly, occasionally can be caught with a troll, and are easily captured with an ordinary hook baited with a piece of bacon rind. The flesh is coarse and the bones are few and large, reminding one of mullet.

In 1844 Chubs' nests were found in the Magalloway River, Maine, by Dr. Jeffries Wyman. He described them to the Boston Society of Natural History (Proceedings, Vol. 1, p. 196) as "mounds of pebbles, two or three feet in diameter, which he was told were heaped up by a fish called the Chub, at its breeding season, and that its eggs were deposited among the stones." He referred to a similar habit attributed to the lamprey eel and remarked that he was not aware of any other instance of the kind.[1] Dr. Robert Bell, in the report of his explorations referred to above, has published a figure of a characteristic nest. He states that a varying number of chubs work together in building a mound, bringing the stones in their mouths, one at a time, from far and near.

In considering the relative sizes of the pebbles and the fish that move them, it must be remembered that under water the weight of the stones will be from one quarter to one third less than the weight in air. In the cases of the larger heaps of stones it is often found that there is an area greater than the base of the cone over which the stones are scattered. In one case we found what appeared to be the base of an old cone and the inference seems to be that in the rebuilding every spring they repair the old nests, shift them at times, and utilize materials from abandoned nests to construct new ones or to enlarge the old. The larger nests are probably the work of several seasons.

MONTREAL, January, 1907

[1] The nests of the lamprey are "gravel filled pockets." "The central part is usually 15 to 20 cms. deeper than the edges, so that the whole is dish-like in appearance; at the lower edge there is always a pile of stones." The stone carrying habit of the lamprey has been described by S. H. Gage, by Dean and Sumner, and by Young and Cole (*American Naturalist*, 1900, vol. 34, pp. 617–620). In an interesting and comprehensive account of parental care among fresh water fishes (*Rep. of the Smithsonian Inst.*, 1905, pp. 402–531) Theodore Gill does not include either the lamprey or the chub, the former presumably not being considered a fish. The cat-fish is described as carrying stones *away* from its nest; no stone gatherer like the chub is mentioned.

NOTES AND LITERATURE

GENERAL BIOLOGY

Mendelism.[1] — In a well printed booklet of eighty-five $4 \times 5\frac{1}{2}$ inch pages, R. C. Punnett of Cambridge, England, has presented an admirably clear and concise account of Mendelism. After reviewing the simple and fundamental experiments of the Abbot of Brünn, the writer describes the more recent discoveries to which they have led, and in conclusion shows them to be of the highest practical and scientific importance. Although the mendelian principles of heredity are well known in America through the publications of Castle, Davenport, and others, a brief review of them as presented by Punnett may still be of interest.

It is found by experiment that when a certain pure bred tall variety of plant is crossed with a dwarf, the resulting hybrid contains both the factors for tallness and shortness. If *A* represents the tall factor of one parent and *a* the short factor of the other the hybrid which contains both is *Aa*. It is not of medium height, but is like its tall parent. A character such as tallness in peas which is retained by the hybrid is called *dominant*: one like dwarfness which is latent in the hybrid is named *recessive*.

When hybrids *Aa* are bred together, they produce in the next generation 25% of pure tall forms, *AA*; 50% of tall hybrids, *Aa*; and 25% of dwarfs, *aa*. The familiar formula may be written thus:

Parents	$\underbrace{AA \qquad aa}$
1st generation	Aa
2nd generation	$\overbrace{AA \quad 2\,Aa \quad aa}$

The tall hybrids *Aa*, and the pure tall plants *AA*, are indistinguishable except by further breeding. Then it appears that one in every three contains only the factors for tallness. Such plants, like the dwarfs, breed as true as if derived from an unbroken ancestry of pure forms.

It is not always the case that the hybrid resembles one of its parents.

[1] Punnett, R. C. *Mendelism*. Second Edition. Cambridge, MacMillan and Bowes, 1907. 16mo. vii + 85 pp.

The blue Andalusian fowl is a race which in breeding produces 25% of black offspring, 50% of blue, and 25% of white splashed with black. It is evident from these proportions that the blue race desired by fanciers is essentially mongrel, and can never be made to breed true. The black race and the splashed whites remain true when each is mated with its own kind, but when crossed they produce the blue Andalusian.

The fixed proportion of pure and mongrel forms in the offspring of hybrids may be readily explained. The factors *A* and *a*, derived by the hybrid from its parents respectively, are transmitted through its germ cells in equal abundance. The factors become segregated, so that one half of the germ cells contains only *A*, and the other half *a*. In the process of fertilization an *A* will unite with *a* as often as with *A*; and an *a* will join *A* as often as *a*. Thus there will be 2 *Aa* for each *aa* and *AA*.

When two different inheritable factors occur in each parent the number of combinations in the offspring is much greater. Mendel found, with peas, that the height of the plant (tall or dwarf) and the color of the seeds (green or yellow) were transmitted independently of one another. *A* and *B* may represent respectively the factors for tallness and greenness which are dominant; *a* and *b* the factors for shortness and yellowness which are recessive. If a tall green-seeded plant *AB*, is crossed with a dwarf yellow *ab*, tall green-seeded hybrids containing the factors *AaBb* result. Every germ cell of such a hybrid contains one factor for height and one for color; they are equally distributed in the four possible combinations *AB*, *Ab*, *aB*, and *ab*. When such a group of germ cells fertilizes a similar group, the following combinations are to be expected:

AA BB	*AA bb*	*aa BB*	*aa bb*
2*AA Bb*	2*Aa bb*	2*aa Bb*	
2*Aa BB*			
4*Aa Bb*			

Thus among sixteen individuals nine contain both dominant factors and in the case of the peas are tall green-seeded plants. Three contain only the dominant *A*, and are tall yellow-seeded forms; three contain only the dominant *B* and are green-seeded dwarfs. One contains neither dominant and is a yellow-seeded dwarf. This ratio, 9:3:3:1 Mendel verified by experiment.

The sweet pea known as the 'Painted Lady' has a bright pink color due to its sap, and this is dominant over the absence of such sap color

in which case the flower is white. In the cream sweet pea there is no sap color, the tint being due to pigmented chromoplasts. The yellow chromoplasts are recessive to colorless ones. Therefore when a Painted Lady is crossed with a cream, the hybrids are all Painted Ladies; in the next generation four classes are found,— Painted Ladies, cream Painted Ladies, whites, and creams, in the proportion 9:3:3:1.

A similar result has been observed in breeding fowls. The rose comb of the Wyandotte type and the pea comb of the Indian game are both dominant over the single comb of the Leghorn type. When a rose comb is crossed with a pea comb a new type results, described as the "walnut" comb. It resembles that of the Malay breed. When such hybrids are bred together four types of comb appear in the next generation, namely the walnut, rose, pea, and single in the proportion of 9:3:3:1.

In rabbits the gray color of the wild animal is dominant over albinism. When a gray is crossed with an albino, gray hybrids result which produce young in the proportion of 9 grays, 3 blacks, and 4 whites. The factors involved are pigmentation, *A*, dominant over albinism, *a*; and grayness, *B*, dominant over blackness, *b*. The four white animals which appear identical include three forms, namely *aa BB*, 2 *aa Bb*, and *aa bb*, all of which lack the pigmentation factor *A*. From this it appears that the wild gray color consists of a factor for pigmentation and another for grayness. By loss of the former a white rabbit results, and by loss of the latter, a black one. In the offspring of such a white and black, *reversion* occurs to the original gray form. Similarly white pea blossoms may each contain one of the two factors for pigmentation, and by crossing such whites, reversion to a wild colored type has been observed. Thus reversion has been defined as a union of complementary factors which have become separated in the course of phylogenetic development.

From these and many other observations, the author concludes that no horticulturalist can propose to raise a tall pea from a dwarf by a process of manuring, nor by selecting minute fluctuations, but only by obtaining new aggregations of unit characters through breeding. He infers that "education is to man what manure is to the pea." — "Permanent progress is a question of breeding rather than of hygiene and pedagogics" for "the creature is not made but born."

In Mr. Punnett's book no reference is made to 'mixed inheritance' whereby the parental characters are blended in the offspring. It must be remembered, however, that rabbits with ears of medium length are obtained by crossing short-eared with lop-eared forms; and that the

crossing of some tall and dwarf plants produces those of intermediate height. The omission of such limitations may cause a student to believe that Mendelism is the universal law of inheritance.

F. T. L.

The Problem of Age, Growth, and Death.— In a series of six public lectures Professor Charles S. Minot has made known the results of his studies, now in progress, concerning the essential nature of senescence. Rejecting such criteria of old age as a halting gait or arterio-sclerosis, which pertain chiefly to man, he has sought those features which apply as well to the aged frog or fish, and even to still lower forms. Such characteristics are found in the decreasing rate of cell division, the increase of protoplasm at the expense of the nucleus, and the progressive differentiation of the protoplasm. Old age is therefore essentially a cytomorphic phase.

The rate of cell division is expressed by the "*mitotic index*" which is the average number of mitotic figures found, in sections, among a thousand nuclei. The mitotic index falls from 18 to 13 in rabbit embryos of $7\frac{1}{2}$ and 13 days respectively. Drawings, on the same scale, of nuclei of the various tissues in rabbit embryos of $7\frac{1}{2}$ to $16\frac{1}{2}$ days show a striking reduction in the actual size of the nucleus, except in the case of the nervous tissue. Even there, in relation to the protoplasmic mass, the nucleus may be relatively small.

The rate of growth begins to decline before birth, and this rate of decline rapidly *decreases* until old age, when growth is at its minimum. The uninterrupted process of senescence was demonstrated by weighings of rabbit embryos of various ages, and of individual guinea pigs, rabbits and chickens, from birth until death. The same law was held to apply to man, both in physical development as shown by statistics of weight, and in mental development as determined by psychologists. During the first months after birth, progress in acquiring concepts of time, space, the ego, and the external world is more rapid than in later years. As with weight, the rate of decline is most abrupt at the outset, becoming gradual as age advances.

The study leads to the paradoxical conclusion that the changes of senescence are most marked in the years of infancy, for the popular idea of maximum efficiency as the mark of maturity is set aside. The embryo in adding an ounce to its weight is rated as advancing more rapidly than the child in gaining a pound; the insect which leaps many times its own length would be regarded as more successful in jumping than the mammal which can far outdistance it.

Because of the rapid early decline in the rate of development Professor Minot believes that the age of college entrance should be lowered, and that professional studies should be entered upon at a younger age. A final publication of these researches, which have extended through many years, is in preparation.

F. T. L.

The Hypothesis of Mimicry.— Dr. Franz Werner of the University of Vienna is a skeptical critic of the *Mimikrylehre* which he regards as due to a rather crude anthropomorphic point of view (*Biol. Centralbl.*, 27, pp. 174–185). He considers first the non-poisonous snakes which are supposed to have acquired a protective resemblance to the poisonous forms of other genera inhabiting the same locality. Since no snake-eating animal is known which makes a distinction between poisonous and non-poisonous forms, the latter cannot be protected by the similarity of pattern. Moreover in some cases there is reason to believe that the non-poisonous snake is the older type and that the venomous Elaps or Vipera is the "imitator." The stingless insects which deceptively resemble bees and wasps fare no better than the harmless snakes, for stinging forms are "not in the least protected from their natural enemies; they fall a prey to many birds as well as to lizards, frogs, toads, and spiders." Finn is cited in evidence that the poisonous Danais is as eagerly devoured in India by lizards of the genus Calotes as are its mimics. Poisonous forms which often exhibit bright warning colors "to signalize their unpalatability to enemies in good season" are not secure.

The similar patterns and colors of various snakes in a given locality may be due to similar climatic conditions and food supply, the pigments involved being physiological by-products. Color photography is invoked to account for the correspondence in color between an animal and its habitat. A physiological rather than a teleological explanation is desired. In other words, it is believed that similar causes produce both the forms which mimic and those which are imitated, and that there is no other relation between the two. From the reports of field observers the number of instances of effective mimicry has been so reduced that "as good as nothing remains." Dr. Werner believes that man alone has been seriously deceived.

F. T. L.

ZOOLOGY

Palms and Soles.— Dr. Schlaginhaufen of Dresden has written a brief description of the palms and soles of man and the apes, based upon a literature of one hundred and fourteen publications.[1] The volar surface of the hand and fingers, and the plantar surface of the foot and toes are thickly covered with slender ridges, the *cristae cutis*, separated from one another by depressions, the *sulci cutis*. Along the summit of a ridge, a row of sweat glands opens. A primitive stage in the formation of the ridges is seen in the Prosimiae, which have small round elevations (*insulae primariae*) surrounding single sweat pores. Besides these primary islands there are larger elliptical forms on which several sweat pores may be arranged in a circle or ellipse, surrounding a central depression. These *lenticular islands* are due to the coalescence of primary islands radially arranged. A crista is formed by the coalescence of a linear series. The *minutiae* of the cristae, upon which personal identification depends, consist in the branches of the ridges, which may end blindly or anastomose; in detached ridges; and in the ridge patterns. The two principal patterns are the more or less concentric *tactile figures*, and the Y shaped groups called *triradii*.

Besides the bas-relief of cristae, palms and soles present the high relief of tactile cushions, *toruli tactiles*. For each extremity there are typically five *digital cushions* at the tips of the fingers or toes; four *interdigital cushions* near the metacarpo- or metatarso-phalangeal joints; and two or three proximal cushions,— a tibial and an elongated fibular, or a radial and two ulnar, one behind the other. This arrangement is typical for pentadactylous mammals and the cushions are well developed in marsupials, rodents, the insectivora and primates. Often the interdigital cushions fuse, as in the cat, and that between the thumb and fingers may be suppressed. Secondary cushions are not infrequent — such as a central cushion found in Cebus — but none occur in the anthropoid apes or in man. Cushions are accumulations of connective tissue and are not to be confounded with eminences due to underlying muscles. On the summits of the

[1] Schlaginhaufen, O. Über das Leistenrelief der Hohlhand- und Fusssohlen-Fläche der Halbaffen, Affen und Menschenrassen. *Ergebn. d. Anat. u. Entw.*, vol. 15, pp. 628-662. Since writing this review, the editor has received the announcement of the following book. Kidd, W. *The sense of touch in mammals and birds with special reference to the papillary ridges.* London, A. and C. Black, 1907. 8vo., 174 figs. 5s.

cushions the complex tactile figures occur, and between them are the triradii and imperfectly formed cristae. The distribution of the triradii in the monkeys and various races of men has been elaborately plotted, showing among other things, the shifting which accompanies the altered function of the foot.

According to Whipple the cushions are essentially walking pads which are secondarily tactile. The cristae have been designated 'friction ridges' since they have been supposed to allow a firmer grasp. An area of furrowed skin has been found on the prehensile tail of Alouatta (Myeetes). The German writers, however, including Schlaginhaufen, regard the cushions as primarily tactile. The most highly developed pads (the digitals) are the most sensitive; the interdigitals are less sensitive; and the low tarsal and carpal cushions least of all. The sensory functions of the toruli, whether primary or secondary, have been demonstrated by various experiments with compass points.

F. T. L.

Literature of Ichthyology. In the Proceedings of the United States National Museum for 1906, (vol. XXXI) are numerous papers on fishes, most of them relating to the fauna of Japan. Jordan and Starks give an elaborate review of the Japanese flounders and soles, 60 species in all. Jordan and Herre discuss the herring-like fishes, and Jordan and Snyder the killifishes. Jordan and Starks give a record of the fishes collected by Prof. J. F. Abbott at Port Arthur, and Hugh M. Smith and Thomas E. B. Pope record the fishes obtained in Japan by Dr. Hugh M. Smith in 1903. Among these are four new genera, *Tosana*, *Satsuma*, *Lysodermus*, and *Lambdopsetta*.

Evermann and Goldsborough describe a new rock-fish, *Sebastodes alexandri*, from California; Evermann and Kendall, a collection of fishes from Argentina; and Evermann and Seale, a collection from the Philippines made by Major Edgar S. Mearns.

In the Proceedings of the United States National Museum for 1907, (vol. XXXII), Jordan and Starks describe a collection of fishes from Santa Catalina Island, California.

Among these are *Germo macropterus*, the yellow-fin Albacore, heretofore known from Japan and Hawaii; *Tetrapterus mitsukurii*, the Marlin-spike fish, heretofore known from Japan; *Lepidopus xantusi*, known from Cape San Lucas; *Chænopsis alepidota*, known from the Gulf of California; and *Luvarus imperialis*, known from the Mediterranean. New species are *Starksia holderi* and *Antennarius avalonis*.

Otohime, a new genus of gurnards (*O. hemisticta*) is described in the same proceedings by Jordan and Starks, from Japan.

In the same Proceedings, Professor John O. Snyder gives a review of the Mullidæ or Surmullets of Japan.

In the Bulletin of the Bureau of Fisheries, vol. XXV, 1905 (issued 1906), are several important papers on the fish-fauna of our island possessions.

The "Fishes of Samoa" by Jordan and Seale contains a list of the species collected on the American island of Tutuila and the German island of Upolu by David Starr Jordan and Vernon Lyman Kellogg in 1902. About 500 species were obtained, 92 of them new to science. Most of the latter are small fishes taken through the use of poison (chloride of lime) in the pools of the reefs. The reef fauna of the islands of Samoa is remarkable for the number of brilliantly colored species. In this paper are twenty-six colored plates of the most strikingly colored of these small reef-fishes, noted since the days of Captain Cook. These plates are from water color sketches by Kako Morita. The origin and purpose of these brilliant hues of coral-reef fishes is one of the most difficult problems in evolution. It is to be noted that these colors are not confined to any one family, but that more than a dozen families of fishes participate in them.

With this paper is a check list of all the species, 1704 in number, now known from the region called *Oceania*, which includes Hawaii, Polynesia, Micronesia, and Melanesia. In all this region the fauna is essentially continuous, except as regards Hawaii. In this separated island group, the genera remain the same as in Polynesia, but the species as a rule are different. This difference is clearly due to the operation of isolation and segregation.

In the same paper is a valuable discussion of the Samoan names of fishes, and the root-words composing them, by Mr. W. E. Safford.

Almost simultaneous with this paper, but apparently with a few weeks priority, is a memoir "Zur Fischfauna der Samoa-Inseln" by Dr. Franz Steindachner, in the "Sitzungsberichte der Kaiserliche Akademie" (1906) in Vienna. Dr. Steindachner describes the species of fishes collected at Apia in Upolu, by Dr. Rechinger. This collection contains 120 species, of which 20 are new. Only one of the new species is contained in the series described by Jordan and Seale. This is *Salarias rechingeri* Steindachner, called *Salarias garmani* by Jordan and Seale. A new genus, *Kræmeria*, is added to the rare family of *Trichonotidæ*.

In the next volume of the Bulletin of the Bureau of Fisheries,

(XXVI), Jordan and Seale discuss the "Fishes of the Islands of Luzon and Panay" as represented in a collection made in 1900 by Dr. George A. Lung, Surgeon in the United States Navy. Dr. Lung obtained at Manila and Iloilo, 249 species, of which eighteen are described as new. One of these species, *Rhinogobius lungi* proves identical with an older species *Rhinogobius nebulosus* (Forskål), and *Petroscirtes vulsus* is the young of *Petroscirtes eretes.*

The same rich fauna is discussed in a similar paper which immediately follows the other in the same Bulletin, "Fishes of the Philippine Islands" by Evermann and Seale. This treats of the collection exhibited at the Louisiana Purchase Exhibition, most of it being obtained by Mr. Charles J. Pierson, formerly of Stanford University. In this collection are 296 species, of which 22 are new.

One of these, *Platophrys palad*, should have been referred to the genus *Pseudorhombus* of Bleeker, of which the American genus *Cencylopsetta* seems to be a synonym. Three other species of *Pseudorhombus* are by some slip of the pen referred to *Platophrys.* It may be noted also that *Amia fasciata* (white) is a species quite different from *Amia novemfasciata.*

Under the title of "Fishes of Australia (Sydney, 1906), Mr. David G. Stead, naturalist to the Board of Fisheries for New South Wales, gives a convenient popular account of the food-fishes of Australia, with a useful record of the vernacular names applied to them. This book is very well written, and contains much unpublished material. It should lead to a general descriptive catalogue of the vast fish-fauna of the Australian continent.

In the Bulletin of the Museum of Comparative Zoology, vol. L, 1906, Dr. Charles R. Eastman describes numerous shark's teeth and cetacean bones found in deep sea dredgings of the Albatross.

In the same bulletin (vol. XLVI, 1906), Dr. Charles H. Gilbert describes certain lantern-fishes in the Museum at Cambridge. *Diaphus nocturnus* Poey is described and figured from the type. A new species, *Diaphus garmani*, is described from Cuba.

In the same bulletin (vol. L, 1906), L. J. Cole and Thomas Barbour describe a collection of vertebrates from Yucatan.

There are 45 fishes, *Rhamdia depressa* and *Rhamdia sacrificii* being new. *Jordanella floridæ*, a characteristic species of the Florida everglades, is reported from near Progreso, and the rare species, *Emblemaria atlantica* and *Corvula sanctæ-luciæ*, from the sea near the same town.

In the Anales del Museo Nacional de Buenos Aires, Dr. Fernando

Lahille describes a remarkable new genus of mackerel-like fishes from Argentina under the name of *Chænogaster holmbergi*. The dorsal and anal fins are provided with finlets; the mouth is very large, and the body is covered with large scales. An allied fish is described by Dr. Lahille from Port Lyttelton, New Zealand, under the name of *Lepidothynnus huttoni*. Both of these are regarded, probably correctly, as related to *Gasterochisma melampus* of New Zealand. Figures of all three of these species are given by Lahille.

In Volume III, of Marine Investigations of South Africa (1905), Dr. J. D. F. Gilchrist, Government Biologist of Cape Colony, describes seventeen new species of fishes found in rather deep water off the Cape of Good Hope. Several of these are most interesting additions to our knowledge of fish-forms.

The Biennial Report of the State Board of Fish Commissioners of California for 1906 contains useful accounts of the trout of California, those of the Sierras by Dr. B. W. Evermann, the others by Dr. D. S. Jordan. The report is edited by Charles A. Vogelsang.

One of the most valuable monographs of a single type of fishes is the magnificent paper entitled, "Chimæroid Fishes and Their Development," by Bashford Dean, published by the Carnegie Institution.

This paper treats especially of the anatomy and development of the California Chimæra called Rat-fish or Elephant-fish, *Chimæra colliei*, as studied in the Hopkins Seaside Laboratory at Pacific Grove in California. The paper contains a record of the other living and fossil species. The final conclusion is that the Chimæroids constitute a highly modified and specialized offshoot from the group of primitive sharks.

In the Transactions of the Zoological Society of London, 1906, Dr. G. A. Boulenger continues his papers on the fresh water fishes of Africa with a memoir on the fishes of Lake Tanganyika.

In the Proceedings of the Royal Academy of Amsterdam, Professor Max Weber discusses the fresh water fauna of New Guinea. He divides these fishes into two groups. The fluviomarine group is derived from the marine fauna of the East Indies. The fluviatile group is derived from the river fauna of Northern Australia. In his view, New Guinea was joined to Australia at a time not later than the Pliocene.

In the Biologia Centrali Americana, published in London (October, 1906), Mr. C. Tate Regan gives an account of the fresh water fishes of Mexico and Central America, a group generously represented in the British Museum. According to Regan, *Eleotris æquidens*, from

Mazatlan, is the same as *Eleotris picta* from farther south. *Dormitator latifrons*, of the Pacific slope, is regarded as different from *Dormitator maculatus* of the Atlantic. The name, *Chonophorus banana*, is used instead of the doubtfully identifiable *Chonophorus* (or *Awaous*) *taiasica*. *Gobius guentheri* is shown to be the same as *Chonophorus transandeanus* and *Awaous nelsoni* may be the same species. *Sicydium multipunctatum* is a new species from Oaxaca. Excellent figures are given of many of the species. In the Annals and Magazine of Natural History, XVIII, 1906, Mr. Regan has numerous papers on fishes. In "Descriptions of Some New Sharks in the British Museum Collection," the Japanese *Orectolobus* is separated from *O. barbatus*, as *Orectolobus japonicus*, and the Japanese Monkfish as *Squatina nebulosa*. This had, however, been earlier named *Squatina japonica* by Bleeker. In another paper in the Proc. Zool. Soc. London for 1906, Mr. Regan discusses the classification of the sharks and rays, proposing a new classification.

The following is Regan's arrangement of the families;

Subclass *Selachii*,

Series 1. *Trematopnea*,

Order 1. *Pleuropterygii* (extinct)

Families, *Cladoselachidæ*.

Order 2. *Acanthodii* (extinct)

Families, *Acanthoessidæ*,
Diplacanthidæ.

Order 3. *Ichthyotomi* (extinct)

Families, *Pleuracanthidæ*.

Order 4. *Euselachii*.

Suborder, *Pleurotremata*,

Division, *Notodanoidea*.

Families, *Chlamydoselachidæ*,
Hexanchidæ.

Division, *Galeoidea*,

Families, *Odontaspididæ*,
Lamnidæ,
Orectolobidæ,
Scylliorhinidæ,
Carchariidæ.

Division, *Squaloidei*,

Families, *Cochliodontidæ* (extinct)
Hybodontidæ (extinct)
Cestraciontidæ,

(*Heterodontidæ*)
Squalidæ,
Squatinidæ.
Suborder 2, *Hypotrema*
Division, *Narcobatoidei*
Family, *Torpedinidæ*
Division, *Batoidei*
Families, *Rhinobatidæ*,
Raiidæ,
Dasybatidæ.
Series II. *Chasmatopnea*,
Order, *Holocephali*,
Family, *Pyctodontidæ* (extinct)
Squaloraiidæ (extinct)
Myriacanthidæ (extinct)
Chimæridæ

The principal feature of this arrangement is the grouping together of the Cestraciont and Squaloid sharks as a division corresponding to the Galeoidea. Except for the reduction of some families to a lower rank, and a few changes in names of groups, this corresponds fairly with that adopted by recent American writers.

Under Diagnoses of New Central American Fresh Water Fishes, Mr. Regan describes *Rivulus flabellicauda*, from Costa Rica, *Rivulus godmanni*, from *Guatemala*, *Pœcilia salvatoris*, from San Salvador, *Xiphophorus strigatus*, from Vera Cruz and Oaxaca, *X. brevis*, from Honduras, *Agonostomus macracanthus* and *A. salvini*, from Guatemala.

In the Anatomischer Anzeiger, Dr. Ulric Dahlgren describes the anatomy of the electric organs on the top of the head in the Electric stargazer, *Astroscopus y-græcum*.

These very interesting organs constitute a new type of electric organs, quite different from those of the torpedoes and other electric fishes.

In the Proceedings of the Academy of Natural Sciences of Philadelphia, Henry W. Fowler describes *Centropomus gabbi* as a new species from San Domingo, and *C. heringi*, from Surinam. He gives a list of the cold-blooded vertebrates obtained about the Florida Keys. Eighty-six species of fishes are recorded, one of them regarded as new. This is *Congrammus moorei*, which seems to the writer a species of *Dactyloscopus*, not evidently different from *Dactyloscopus tridigitatus*, found by him at Key West.

In a paper on "Rare or little known Scombroids, No. 3," Mr. Fowler proposes the new subgenus *Pampanoa* for *Trachinotus glaucus*, distinguished by the falcate fins. *Stromateus brasiliensis* is described as new from Brazil, and *Psenes chapmani*, from the Sargasso Sea.

Mr. Fowler in this and other papers adopts the generic names of Klein, published about 1740, and pre-Linnæan as well as non-binomial. These names, in his view, become available, because Walbaum in 1792 reprinted them all with their diagnoses, although not adopting them or in any way reinforcing them. In the judgment of most writers, a name published before Linnæus does not acquire validity by a reprint without acceptance. This is a matter on which some definite ruling should be made.

If we adopt these names of Klein, *Psallisostomus* will replace *Lepisosteus* or *Lepidosteus*, *Brama* will replace *Abramis*, and *Glaucus Lichia*.

A review of various genera of South American Characins is given by Mr. Fowler, as also series of useful notes on fishes of Pennsylvania.

In the Bulletin of George Washington University, vol. I, 1906, Dr. Theodore Gill tells "the remarkable story of a Greek fish, the Glanis," (*Parasilurus aristotelis*). This species was known to Aristotle, but modern authors have, with a few exceptions, overlooked its existence.

In the Smithsonian Report for 1905, Dr. Theodore Gill gives an interesting review of our knowledge of "Parental Care among Fresh Water Fishes." The literature of this subject is fully discussed.

In the Zoologischer Anzeiger, Dr. L. S. Berg discusses the fishes of Lake Baikal and those of the Amur Basin. He considers *Cottocomephorus* as the type of a distinct family. This is based mainly on the peculiar structure of the caudal vertebræ. The fishes of Turkestan are also listed by the same author.

In the Bulletin of the Académie Impériale des Sciences, L. Berg discusses the lampreys of the Russian Empire.

The species of *Lampetra* or river lamprey in this vast region he reduces to two, *L. fluviatilis* and *L. planeri*. To the former he refers *Lampetra aurea* of Alaska, *L. japonica* of Japan, *L. camtchatica* of Kamchatka and other nominal species.

Lampetra planeri, according to Berg, includes *L. mitsukurii* of Japan and *L. wilderi* of the Eastern United States. This last determination is certainly doubtful.

In the Proc. Zool. Soc. London, Prof. W. B. Benham and W. J. Dunbar describe the skull of a young Ribbon-fish, *Regalecus*, from New Zealand.

In the 24th Annual Report of the Fishery Board for Scotland, Dr. H. C. Williamson describes the small cod-fish, *Gadus minutus* and *Gadus esmarki*, and records two cases of hermaphroditism in the common cod-fish.

The fourth part of the Fishes of Japan by Otaki, Fujita and Higurashi appears with descriptions in English and Japanese and with excellent colored figures of the common 'Tai,' the "national fish" of Japan, (*Pagrus major*), of the Ayu (*Plecoglosmus altivelis*), next to the American Eulachon, the finest of all food-fishes, and other species of interest.

In the Zoological Series of the Field Columbian Museum, Dr. T. H. Bean publishes a catalogue of the Fishes of Bermuda. 261 species are recorded, many of the more rare forms being figured. The new species, previously described in the Proceedings of the Biological Society of Washington, vol. XIX, for 1906, are the following: *Hippocampus brunneus*, (= *H. hudsonius* Jordan & Evermann, not of DeKay), *Holocentrus meeki*, *Eupomacentrus chrysus*, *Iridio decoratus*, *Iridio meyeri*, *Iridio microstomus*, *Cryptotomus crassiceps*, *Monacanthus tuckeri*, *Rhinogobius mowbrayi*, *Labrisomus lentiginosus*, *Antennarius verrucosus*.

In the series of Occasional Papers of the Bernice Pauahi Museum at Honolulu Alvin Seale gives a list of "Fishes of the South Pacific" collected by him in the Marquesas, Tahiti, Solomon Islands, and elsewhere in the South Seas. Numerous new species are described, and illustrated in not very satisfactory fashion by photographs.

In the same series, William A. Bryan describes a few new or rare fishes from Honolulu.

In the Records of the Australian Museum, VI, 1906, Edgar R. Waite gives descriptions of Australian and Tasmanian fishes, and studies in Australian Sharks, with photographs of the egg cases of certain species.

In the Proceedings of the Biological Society of Washington, Hugh M. Smith and Alvin Seale describe a number of species from the Philippines, four species being new.

In the Bulletin of the Michigan Fish Commission, No. 8, Mr. Ellis L. Michael catalogs the fishes of Michigan, with reference to all Michigan notices of each species.

DAVID STARR JORDAN.

Nettling Hairs of the Brown-tail Moth.[1] — It is well known that

[1] Tyzzer, E. E. The pathology of the brown-tail moth dermatitis. *Journ. of Med. Res.*, vol. 16, pp. 43–64.

certain barbed hairs from caterpillars of the brown-tail moth, when applied to the skin, may cause a severe inflammation. Dr. Tyzzer has found that these hairs occur over "two velvety brown spots which appear on the dorsal aspect of the fifth and sixth segments after the first molt." Similar spots are found after each succeeding molt up to the last two spring molts, when they appear on all segments from the fifth to the twelfth inclusive. At this time they occur also in relation with the lateral tubercles of the same segments, so that the caterpillar becomes much more poisonous than in its young stages. The tapering nettling hairs are inserted by their pointed ends into elevations upon the caterpillar; the barbs, which at intervals tend to encircle the hair, point outward. If these hairs, which are easily detached, are rubbed upon the skin they work their way inward, pointed end foremost. It was supposed that the irritation which followed was purely mechanical. Dr. Tyzzer has demonstrated a chemical poison in the following manner. If the hairs are placed in a drop of blood between a slide and cover glass, a modification of the red corpuscles takes place at the apex of the hair. There the rouleaux are broken up; the corpuscles shrink and become at first spiny, and then spherical. That this is not a physical phenomenon is shown by substituting hairs of similar shape from the tussock moth, when no reaction occurs. It is believed that a poisonous substance is emitted from the apex of the hair, although no pore is visible. If the hair is broken the reaction occurs about the fracture, but otherwise only at the pointed extremity. The poisonous substance is not destroyed by baking the hairs for one hour at 110° C, but is destroyed at 115°. In the latter case the hairs produce no dermatitis when applied to the skin, and no reaction in the drop of blood. The poison is insoluble in alcohol, acetone, chloroform, ether, acetic acid, and dilute hydrochloric acid. It appears, however, to dissolve in distilled water at 60° C, and a further chemical study is in progress.

In regard to animal coloration it may be noted that the caterpillars of the tussock moth, said to present 'warning colors,' have non-poisonous hairs; those of the Io moth, with a green 'protective coloration' are somewhat poisonous; and the poisonous brown-tail caterpillars have neither a warning nor a protective color. All three forms, moreover, are eaten by birds.

F. T. L.

Divided Eyes of Insects.— G. D. Shafer has studied the divided eyes in certain Odonata and Diptera [1] and has followed the late stages

[1] Proc. Washington Academy of Science, **8**, 1907.

of their development in two species. The modifications are introduced in the nymph stage and are almost complete in the subimago, though the eyes rapidly increase in size at the time of the final molt. Shafer thinks that the two divisions of the eye are for vision in different kind of light the regions with larger elements and less dense pigmentation being available in twilight or in the darker hours.

Notes.— Dr. Lawrence E. Griffin has published in the Missouri Valley College Quarterly Bulletin, (**6**, No. 4, 1907) a handy guide to the dissection of the dogfish (Acanthias & Galius). Copies may be had from the author at Marshall, Missouri, at 25 cents each.

BOTANY

Winter Rest.— In a very comprehensive series of experiments,[1] in one of which as many as 283 species were used, Dr. Walter L. Howard, of Columbia, Mo., has studied the effect of increase of temperature, narcotics, lack of light, and dehydrating agents upon plants in the resting condition. He comes to the conclusion that the resting period is due to external influences, which also determine its duration and intensity. It may be interrupted by the use of the above mentioned agents. Though the results they produce are identical, their action is different. An ample citation of literature enhances the value of this paper.

Henri Hus.

Notes.— A quarto of 340 pages, devoted to a revision of the genus Lepidium by Thellung, has been separately issued from vol. 41 of the *Neue Denkschriften der Allgem. Schweizerischen Gesellschaft f. d. Gesamten Naturwissenschaften*, as a contribution from the Zürich Botanical Museum.

Some of the difficulties of cactus study are pointed out by Griffiths and Hare in an economic leaflet issued as *Bulletin no. 102, part 1*, of the Bureau of Plant Industry, U. S. Department of Agriculture.

Observations on Sarracenia are published by Macfarlane in *The Journal of Botany* for January.

[1] Howard, Walter L. Untersuchung ueber die Winterruheperiode der Pflanzen. Inaugural-dissertation, Halle, 1906. pp. 111.

Opuntia pusilla as a Cape weed is discussed by Nobbs in *The Agricultural Journal of the Cape of Good Hope* for December.

Illustrations of the celebrated cypress of Tule are given in *Forest Leaves* for December.

Notes on rare ferns about Media, Pa., and especially *Asplenium ebenoides*, are given by Palmer in vol. 2, no. 1 of the *Proceedings of the Delaware County Institute of Science.*

From notes in *Nature* of December 13 and January 10, it appears a subject of debate whether *Sphærotheca mors-uvæ* is a new pest in England or one of 30 years' standing.

Berghs gives an account of the nuclear phenomena of Spirogyra in vol. 23, fascicle 1 of *La Cellule.*

Cruchet publishes on Labiate rusts in the *Centralblatt für Bakteriologie &c.*, Abteilung II., of Dec. 28.

The biology of the sand areas of Illinois is the subject of vol. 7, article 7, of the *Bulletin of the Illinois State Laboratory of Natural History*, by Hart and Gleason.

A short readable exposition of his views on evolution and mutation is given by DeVries in *The Monist* for January.

An illustrated handbook of "The Microscopy of Vegetable Foods" with special reference to the detection of adulteration and the diagnosis of mixtures, by Winton and Moeller, has recently been issued by John Wiley and Sons of New York and Chapman and Hall of London.

The flora of the Cuban 'Sierra Maestra' is considered in a forestry study reported by Fernow and Taylor in the *Forestry Quarterly* of December.

Tobacco-culture experiments, by Hunger, occupy part 3 of the current volume of *Archives du Musée Teyler.*

Guayule (Parthenium) rubber is the subject of a statistical note in *Tropical Life* for December.

The Christmas number of *The Southern Lumberman* contains a number of well illustrated articles on native trees.

The activities of the Desert Laboratory at Tucson are outlined by MacDougal in the recently issued *Year Book*, No. 5, of the Carnegie Institution of Washington.

Vol. 5, no. 16 of the *Bulletin of the New York Botanical Garden* forms a general descriptive guide to the grounds, buildings and collections.

The Report of the Michigan Academy of Science, vol. 8, contains the following papers of botanical interest:— Kauffman, 'Unreported Michigan Fungi. . . .'; Beal, 'A Study of *Rudbeckia hirta*,' and 'Some Botanical Errors Found in Agricultural and Botanical Text-Books.' Dandeno, 'A Stimulus to the Production of Cellulose and Starch,' 'A Fungus Disease of Greenhouse Lettuce,' and 'The Aerating Systems of Plant Tissues'; Pennington, 'Plant Distribution at Mud Lake'; Smith, 'Some Notes on Nodules'; and Sackett, 'The Association of *Pseudomonas radicicola* with *Bacillus ramosus*.'

W. T.

CORRESPONDENCE

Editor of the American Naturalist:

The Flying Fish problem, discussed by Lieut. Col. C. D. Durnford in the American Naturalist for February (page 65), seems to be now reduced to a question of keenness of eyesight. Do the wings or pectoral fins of this fish in flight move so swiftly that the motion cannot be seen? or do they not move at all?

The initial start of the fish on leaving the water is clearly due to the swift motion of the tail. When the tail is moving, either at the initial leap from the water, or when by skimming along the surface the tail touches the water, the wings are seen to be in rapid vibration. When the tail is free from the water, the wings are outspread fan-fashion and seem to be held firmly and at rest without vibration, to be folded when the fish drops into the water. It takes strong muscles to hold the wings taut; we may admit that the fish has these; it would take stronger muscles to cause the fish to move through the flapping of the wings.

The problem is this: Does the fish flap its fins? In the view of Col. Durnford it does. In his view the vibrations are so rapid that to most observers they cannot be seen, except at the beginning or end of the flight, when the tail is in the water.

In the view of others, the wings are not flapped at all. When the fish rises from the body the tail is flapped, which flaps the body and causes the wings to vibrate up and down as the body itself is agitated.

The writer has watched many hundreds of flying fishes. His best opportunity has been in a small boat in the Santa Catalina Channel, where the largest of the known species, *Cypselurus californicus*, over a foot long, flies by the hundred in March. He is reasonably sure, so far as any man can trust his own eye, that the *wings do not move* when the fish is sailing, and that that portion of the fish's flight is on the principle of the aeroplane.

The following note was made by the writer in 1880:

"Their movements in the water are extremely rapid; the sole source of motive power is the action of the strong tail while in the water. No force is acquired while the fish is in the air. On rising from the water, the movements of the tail are continued until the whole body is out of the water. While the tail is in motion, the pectorals seem to

be in a state of rapid vibration, but this is apparent only, due to the resistance of the air to the motions of the animal. While the tail is in the water, the ventrals are folded. When the action of the tail ceases, the pectorals and ventrals are spread and held at rest. They are not used as wings, but act rather as parachutes to hold the body in the air. When the fish begins to fall, the tail touches the water, when its motion begins again, and with it the apparent motion of the pectorals. It is thus enabled to resume its flight, which it finishes with a splash. While in the air it resembles a large dragon-fly. The motion is very swift, at first in a straight line, but later deflected into a curve. The motion has no relation to the direction of the wind. When a vessel is passing through a school of these fishes, they spring up before it, moving in all directions, as grasshoppers in a meadow."

Very truly yours,

David Starr Jordan

February 23, 1907

PUBLICATIONS RECEIVED.

(Regular exchanges are not included)

HAWKES, C. *The Trail to the Woods.* New York, American Book Co., 1907. 12mo, 176 pp., illus. 40 cts.— KEFFER, C. A. *Nature Studies on the Farm.* New York, American Book Co., 1907. 12mo, 154 pp., illus. 40 cts.— LE DANTEC, F. *Eléments de Philosophie biologique.* Paris, Félix Alcan, 1907. 8vo, vi + 297 pp. 3 fr. 50.— LINVILLE, H. R., AND KELLY, H. A. *A Guide for Laboratory and Field Work in Zoölogy.* Boston, Ginn & Company, 1907. 12vo, vi + 104 pp., illus. 45 cts.— MCPHERSON, W., AND HENDERSON, W. E. *Exercises in Chemistry.* Boston, Ginn & Company, 1907. 12vo, xii + 69 pp., illus. 45 cts.— DE NUSSAC, L. *Les débuts d'un savant naturaliste, le prince de l'entomologie, Pierre-André Latreille, à Brive de 1762 à 1798.* Paris, G. Steinheil, 1907. 8vo, 264 pp., 2 pls. 5 fr.

ALBERT I, PRINCE DE MONACO. Sur la huitième campagne de la *Princesse-Alice II. Bull de l'Inst. Océanog. de Monaco.* No. 95, 4 pp. — ALLEMANDET, G.-H. Analyse de quelques échantillons de Pélagosite recueillis dans le port de Monaco. *Bull. de l'Inst. Océanogr. de Monaco,* no. 91, 11 pp. — BARTSCH, P. A new mollusk of the genus Macromphalina from the west coast of America. *Proc. U. S. Nat. Mus.,* vol. 32, p. 233.— BELL, A. G. Aerial locomotion. *Proc. Washington Acad. Sci.,* vol. 8, pp. 407–448, pls. 9–20.— BOUVIER, E.-L. Quelques impressions d'un naturaliste au cours d'une campagne scientifique de S. A. S. le Prince de Monaco (1905). *Bull. de l'Inst. Océanogr. de Monaco,* no. 93, 93 pp., 69 figs.— BUREAU OF FISHERIES. Statistics of the middle Atlantic States for 1904. *Document No. 609.* The distribution of food fishes during the fiscal year 1906. *Document No. 613.*— CARD, F. W. Corn selection. *R. I. Agric. Exp. Sta.,* bull. 116. 35 pp., 9 figs.— COBB, N. A. Fungus maladies of the sugar cane, with notes on associated insects and nematodes. *Rep. of the Exp. Sta. of the Hawaiian Sugar Planters' Assoc.,* bull. 5, 2nd ed., 254 pp., 101 figs., 7 pls.— EDWARDS, H. T. The cultivation of Maguey in the Philippine Islands. *Dept. of the Int., Bur. of Agric.,* Farmers' Bull. 13, 25 pp., 9 pls.— EIGENMANN, C. H. On a collection of fishes from Buenos Aires. *Proc. Washington Acad. Sci.,* vol. 8, pp. 449–458, pls. 21–23.— ELLIOT, D. G. A catalogue of the collection of mammals in the Field Columbian Museum. *Field Columbian Mus.,* zoöl. ser., vol. 8, pub. 115, pp. 1–694, 92 figs.— GÁNDARA, G. La anguilula del cafeto. *Com. Parasitol. Agric., México,* circ. 51, 7 pp., 6 figs.— GREENMAN, J. M. Studies in the genus Citharexylum. *Field Columbian Mus.,* bot. ser., vol. 2, pub. 117, pp. 185–190. — HARTWELL, B. L. Analyses of commercial fertilizers. *R. I. Agric. Exp. Sta.,* bull. 117, pp. 39–52.— HRDLIČKA, A. Measurements of the cranial fossae. *Proc. U. S. Nat. Mus.,* vol. 32, pp. 177–232, pls. 14–15.— INDA, J. R. Las mantas ó campamochas. *Com. Parasitol. Agric., México,* circ. 54, 14 pp., 2 figs.— JORDAN, D. S. A review of the fishes of the family Histiopteridæ, found in the waters of Japan; with a note on Tephritis Günther. *Proc. U. S. Nat. Mus.,* vol. 32, pp. 235–239.— JOUBIN, L. La Presqu'île de Quiberon.

Bull. de l'Inst. Océanog. de Monaco, no. 92, 24 pp., 19 figs., 4 pls.— JUDAY, C. Ostracoda of the San Diego region. II. Littoral forms. *Univ. of Cal. Publ., Zool.*, vol. 3, pp. 135–150, pls. 18–20.— JUDAY, C. Cladocera of the San Diego region. *Univ. of Cal. Publ., Zool.*, vol. 3, pp. 157–158, 1 fig.— MILLSPAUGH, C. F. Flora of the sand keys of Florida. *Field Columbian Mus.*, bot. ser., vol. 2, pub. 118, pp. 191–243, 19 maps.— MOORE, H. F. Survey of oyster bottoms in Matagorda Bay, Texas. *Bureau of Fisheries*, doc. 610, 86 pp., 13 pls., 1 map.— NELSON, A. Some potato diseases; their cause and control. *Wyoming Exp. Sta.*, bull. 71, 39 pp., 11 figs.— NOWELL, H. T. Duty of water on field pease. *Wyoming Exp. Sta.*, bull. 72, 16 pp., 4 figs.— SCHAEFFER, C. New Bruchidæ, with notes on known species and list of species known to occur at Brownsville, Texas, and in the Huachuca Mts., Arizona. *Brooklyn Inst. of Arts and Sci.*, vol. 1, pp. 291–306.— SCHLAGINHAUFEN, O. Über das Leistenrelief der Hohlhand und Fusssohlen-Flächen der Halbaffen, Affen, und Menschenrassen. *Ergebn. d. Anat. u. Entw.*, vol. 15, pp. 628–662, 14 figs.— SCHLAGINHAUFEN, O. Beschreibung und Handhabung von Rudolf Martins diagraphentechnischen Apparaten. *Korrespondenzbl. d. Deutsch. Gesellsch. f. Anthr. Ethn. u. Urgeschichte*, vol. 38, pp. 1–6, 4 figs.— SCHLAGINHAUFEN, O. Ein Canalis craniopharyngeus persistens an einem Menschenschädel und sein Vorkommen bei den Anthropoiden. *Anat. Anz.*, vol. 30, pp. 1–8, 5 figs. — SHAFER, G. D. Histology and development of the divided eyes of certain insects. *Proc. Washington Acad. Sci.*, vol. 8, pp. 459–486, pls. 24–27.— SPRINGFIELD MUSEUM OF NATURAL HISTORY. Bird migration; dates of arrival of birds within ten miles of Springfield, Mass., from 1901 to 1906.— VLÈS F. Sur l'existence de la Mye dans la Méditerranée. *Bull. de l'Inst. Océanog. de Monaco*, no. 94, 2 pp.— WILCOX, W. A. The commercial fisheries of the Pacific Coast States in 1904. *Bureau of Fisheries*, doc. 612, 74 pp.

BOLETÍN DE LA SOCIEDAD ARAGONESA DE CIENCIAS NATURALES, vol. 6, no. 1. BULLETIN BIOLOGIQUE, DORPAT, RUSSIA, no. 1. BULLETIN OF THE CHARLESTON MUSEUM, vol. 3, no. 2. SECOND REPORT OF THE WELLCOME RESEARCH LABORATORIES AT THE GORDON MEMORIAL COLLEGE KHARTOUM.

(No. 484 was issued May 1, 1907)

The first of a series of Colored Plates of the

THRUSHES
OF
NORTH AMERICA

By FUERTES & HORSFALL,

was published in BIRD-LORE for February.

The series will be concluded this year

---

20 CENTS A COPY. $1.00 A YEAR

THE MACMILLAN CO.

NEW YORK CITY

The Great English Magazines

DO YOU know them—know what they are publishing—read them—subscribe for them? There are THE EDINBURGH REVIEW and the QUARTERLY; the CONTEMPORARY, FORTNIGHTLY, MONTHLY, INDEPENDENT, WESTMINSTER, and NINETEENTH CENTURY REVIEWS; BLACKWOOD'S, CORNHILL, MACMILLAN'S, GENTLEMAN'S, and PALL MALL MAGAZINES; the SPECTATOR, the SATURDAY REVIEW, the SPEAKER, the OUTLOOK, PUNCH and others. No matter how many American magazines you read, you need to know something of our English contemporaries. The one convenient, sensible, inexpensive way is to subscribe for **The Living Age,** which gives every week the best contributions from current numbers of the foreign periodicals. Its scope includes literature, science, history, politics—especially timely discussions of public affairs; travel and exploration: essays, reviews and criticisms; fiction—both serial and short stories. President Roosevelt, Chief Justice Fuller, and thousands of other people who want to be cosmopolitan in their reading are subscribers for **The Living Age.** Founded in 1844. $6 a year, $1 for 3 months' trial. Specimen copy free.

ADDRESS

THE LIVING AGE CO.

6 Beacon Street, . Boston, Mass.

VOL. XLI, NO. 486 JUNE, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

Page

I. A Graphic Method of Correlating Fish Environment and Distribution
ALBERT H. WRIGHT 351

II. The Microgametophyte of the Podocarpineæ
E. C. JEFFREY and M. A. CHRYSLER 355

III. The Problem of Color Vision . . . . . JOHN M. DANE 365

IV. The Breeding Habits of *Amblystoma punctatum* Linn. BERTRAM G. SMITH 381

V. The Staff-tree, *Celastrus scandens*, as a Former Food Supply of Starving Indians . . . . . FRANK T. DILLINGHAM 391

VI. Notes and Literature: *General Biology;* The spirit of nature study.—Heterogenesis. *Zoology;* Anatomical terminology.—The blending and overlap of instincts in birds.—Variation of scutellation in the garter snakes.—A method for removing the gelatinous coats of eggs.—The star-nosed mole on Long Island, N. Y.—Notes. *Botany;* Cytology and mutation.—Variation and differentiation.—Cotton.—Notes. *Geology;* The elements of geology 395

VII. Publications Received 411

BOSTON, U. S. A.

GINN & COMPANY, PUBLISHERS

29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington.*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley.*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.Sc., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington.*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York.*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology, Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *June, 1907* No. 486

A GRAPHIC METHOD OF CORRELATING FISH ENVIRONMENT AND DISTRIBUTION

ALBERT HAZEN WRIGHT

IT is some years since ornithologists saw the advantages of a graphic means of representing complex bird waves and their coincident relation to physical conditions. In ichthyology a schematic method whereby fish distribution and environment can be correlated is not less valuable.

The study of a stream and its fishes involves the consideration of factors so numerous and so diverse, and accumulates such a mass of data, that one is impelled to adopt some graphic method to make results appear quickly and clearly.

The chart to be described presently (Fig. 1) is of a hypothetic stream, including a variety of possible conditions. The first continuous vertical line to the right of the list of species represents the mouth of the stream, and the corresponding vertical on the right of the chart is its source. The dotted verticals numbered below (1–8) mark mile points. Beneath the "Misc. Data" space, these mile lines are not dotted but continuous.

The heavy horizontal opposite each species indicates the range of that species in the stream. Wherever the horizontal is broken, it indicates the occasional occurrence of the species. Whenever a species gains entrance to a stream from two or more points an arrow tip at the end of each of its range lines indicates the direction of its migration; *e. g.*, in our hypothetic stream the carp, *Cyprinus carpio* enters from the mouth and from canal overflows.

The continuous horizontal above the first species in the list, represents the surface of the water. The bottom is shown by the curved line labeled "Bottom of Stream." The average depth

at any given point is, therefore, the vertical between these two lines, read from the scale at the extreme right of the chart.

The continuous horizontal immediately below the last species enumerated, represents the altitude of the mouth above sea-level. The profile line indicates the drop in the stream. The approximate altitude of any given point along the stream is shown by the vertical between the two above mentioned lines, and read from the scale at the right.

The continuous horizontal in "Valley Cross Sections" represents the stream, on either side of which is shown a section of the country for one and a quarter miles. In these cross sections at every mile point the geologic formation can be indicated.

The current, width and bottom data are self explanatory. In the "Miscellaneous Data," bridges, marshy regions, dams, etc., are represented so far as possible, by the conventional signs employed by the U. S. Geological Survey, thus:

Bridges.....	(A)	*e. g.*, below the one mile mark, at the two mile mark, etc.
Woodlands.....	(B)	" at the one mile mark.
Swamp.....	(C)	" between the one and two mile marks.
Important Tributary	(D)	represented by a forked wavy line. The position of the tributary line in the upper or lower part of the "Misc. Data" space indicates that the tributary enters the stream from the right or left side respectively.
		" at the 1.25 mile mark. (Enters from the left side.)
		" at the 2.6 mile mark. (Enters from the right side.)
Falls.....	(E)	" on either side of the four mile mark.
Dams.....	(F)	" at the 5.6 mile mark.
Remains of a Dam..	(G)	" at the seven mile mark.
Small Tributary....	(H)	represented by an unforked wavy line.
		" at the 5.8 mile mark. (Enters from the right side.)

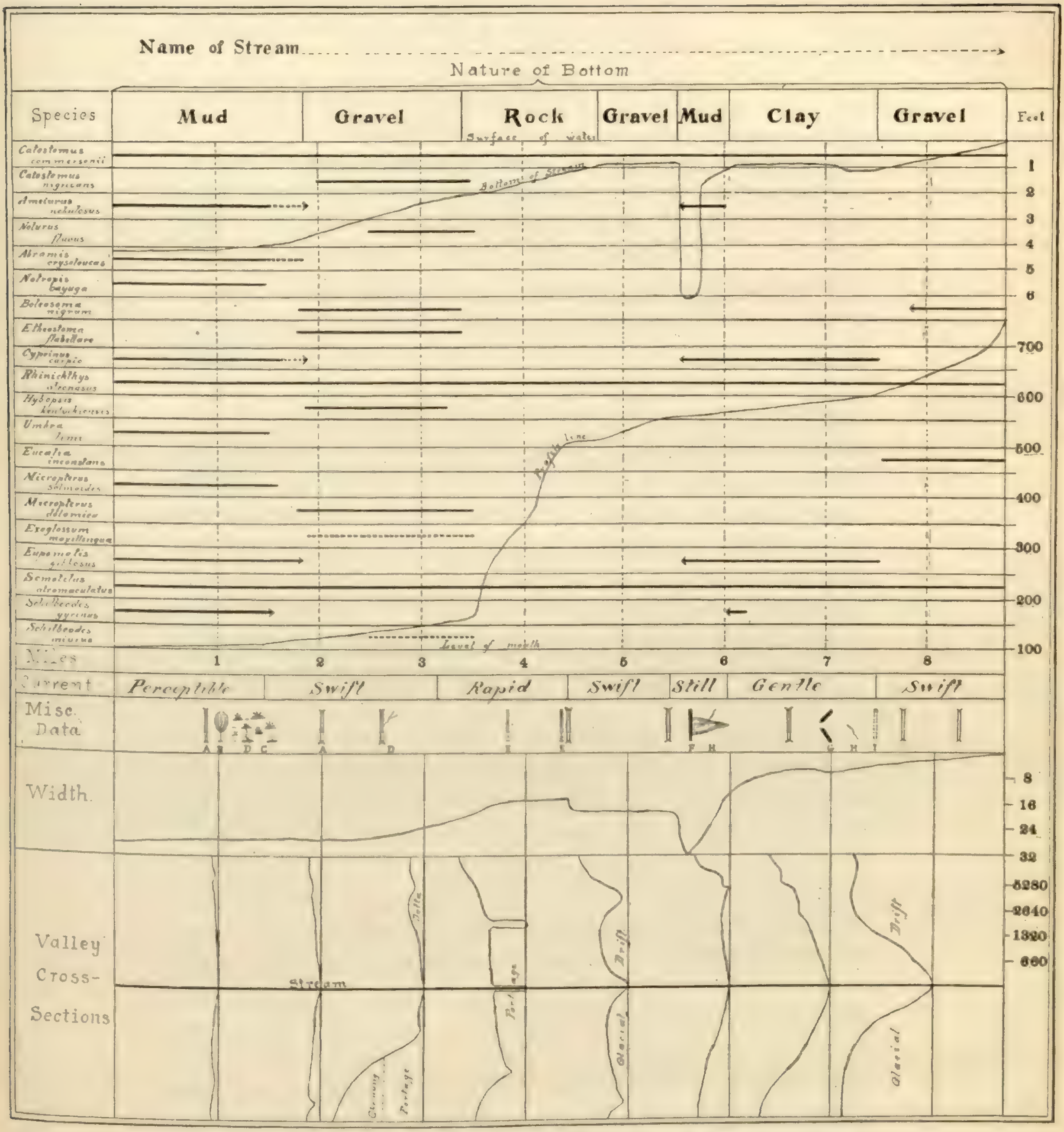


FIG. 1.— A Hypothetic Chart Correlating Fish Environment and Distribution.

Explanation of Miscellaneous Data.

A.....Bridge.
B.....Woodlands.
C.....Swamp.
D.....Important Tributary.
E.....Falls.
F.....Dam.
G.....Remains of a Dam.
H.....Small Tributary.
I.....Canal.

e. g., at the 7.25 mile mark. (Enters from the left side.)
Canal.....(I) " at the 7.5 mile mark.

Taking the common bullhead, *Ameiurus nebulosus*, as an example, one is able to read from the chart, concerning its distribution, etc., the following: it is common in the lower two miles of the stream, gradually decreasing in abundance at the end of the second mile. Throughout the middle course where rock or gravel bottoms and swift water or rapids occur this species is absent. In the upper course where the current and bottom are influenced by the dam, located 5.5 miles from the mouth, it reappears. In the latter instance, its presence so near the headwaters is due to canal overflows at the 7.5 mile point. It seldom frequents water less than 4 feet deep. In both ranges, the drop in the stream is slight, so that the current is just perceptible at the mouth, and imperceptible at the dam. At these two points the stream's width is respectively 27 and 32 feet. In both places a muddy bottom obtains. In the lower course the stream lies on a delta formation while in the upper course the underlying stratum is glacial drift.

The Johnny darter, *Boleosoma nigrum*, occurs at the source of the creek, due to a contribution at floodtime from another stream across the divide, the two sources being on the same level and continuous at some seasons. The falls on either side of the 4 mile point would preclude its reaching the source from the mouth.

One objection to the chart, which appears serious at first, is its failure to show migration within the stream. If a stream, however, be charted in this way in the spring, summer and autumn and a comparison of the three charts be made, many interesting deductions might be drawn. Should it seem desirable to make the work more intensive, to restrict it to a limited portion of a stream and to a single species, daily surveys might be made and the results embodied in one chart. The date of each daily survey could be placed in the spaces now occupied by the specific names and the range line for the day constructed opposite the date.

CORNELL UNIVERSITY
Ithaca, N. Y.

THE MICROGAMETOPHYTE OF THE PODOCARPINEÆ[1]

E. C. JEFFREY AND M. A. CHRYSLER

ALTHOUGH at the present time the views in regard to the relationships of the Coniferales depend very largely on the study of their gametophytic or sexual generation, our knowledge in regard to the gametophyte of the coniferous families is often very meager. The two families concerning which information is actually most needed are the Podocarpineae and the Araucarineae, exotics confined chiefly to the southern hemisphere. There is a prospect that our ignorance in regard to the Araucarineae will soon be less dense than it is at present, a consummation devoutly to be desired on account of the prevailing views, which make them the most ancient of the Coniferales. It is proposed in the present article to describe certain features of the male sexual generation of the Podocarpineae observed in material which we owe to the kindness of Dr. Cockayne of Christchurch, New Zealand, and Dr. Treub, Director of the Royal Gardens at Buitenzorg, Java. To both of these we tender our very warm thanks for the unfailing good nature which has made it possible for us to study some of the Australasian genera of the Podocarpineae. The material at our disposal was fixed in formaline or alcohol and consequently leaves something to be desired in the preservation of cytological details. As we shall however confine ourselves to the gross features of nuclear structure which do not suffer seriously by the methods of preservation described, this will not be a serious disadvantage.

The first species to be considered is *Podocarpus polystachya*, material of which we owe to Dr. Treub, Director of the Botanic Gardens at Buitenzorg. The male cones in our possession are in various stages of anthesis; but some of them show quite young anthers or microsporophylls in the upper region of the axis. This feature has made it possible for us to follow step by step the development of the male gametophyte up to the time of the shed-

[1] Contributions from the Phanerogamic Laboratories of Harvard University. No. 8.

ding of the pollen or microspores, in spite of the fact that the material represents a single collection. *A* figure 1, represents the first mitosis in the microspore, which it will be observed is well advanced toward completion. The state of preservation of this material is remarkable in view of the fact that it was fixed in strong alcohol. In *b* figure 1, is to be seen the first prothallial cell fully formed and lying over against the upper or *posterior* side of the microspore. Beneath it, is the residual nucleus surrounded by vacuolated protoplasm. In *c* figure 1, is to be seen the mitosis which precedes the formation of the second prothallial cell. In *d*

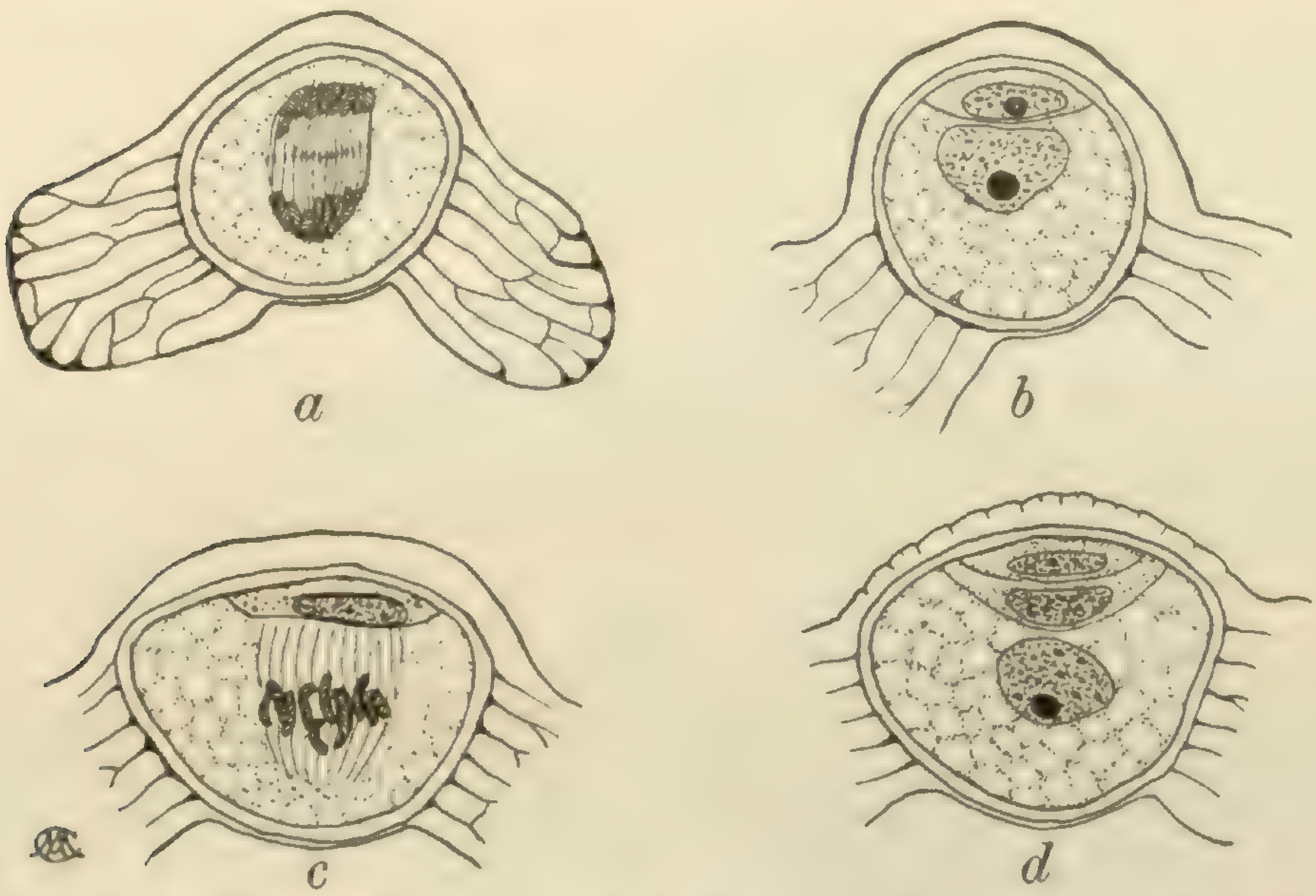


FIG. 1.— *Podocarpus polystachya*. *a*, First division of microspore. *b*, First prothallial cell cut off. *c*, Cutting off of second prothallial cell. *d*, Two prothallial cells cut off. × 925. The lateral air chambers, completely shown in *a*, are one of the numerous features of resemblance between the pollen of the Podocarpineæ and that of the Abietineæ.

figure 1, the second prothallial cell is complete and lies against the first. At about this time the strongly thickened posterior wall of the microspore, which seems to be a peculiar feature of podocarpineous pollen, becomes markedly sculptured as is shown in *d*. In *a* figure 2, is shown a still later phase where the so-called generative cell has become added to the prothallial cells, which lie on the posterior wall of the microspore; it arises from another division of the residual nucleus. The contents of the pollen grain at this stage resemble in detail the conditions to be found in the abietineous microspore before the prothallial cells have begun to degenerate.

In Podocarpus however there is no atrophy of the prothallial rudiments at this stage, but they undergo further changes of a surprising character, comparable only to those recently described by Thomson[1] in the genus Araucaria. In *b* figure 2, a later stage of development is shown, in which each of the prothallial cells has undergone transverse or anticlinal division. Division generally takes place first in the outer prothallial cell lying next the wall

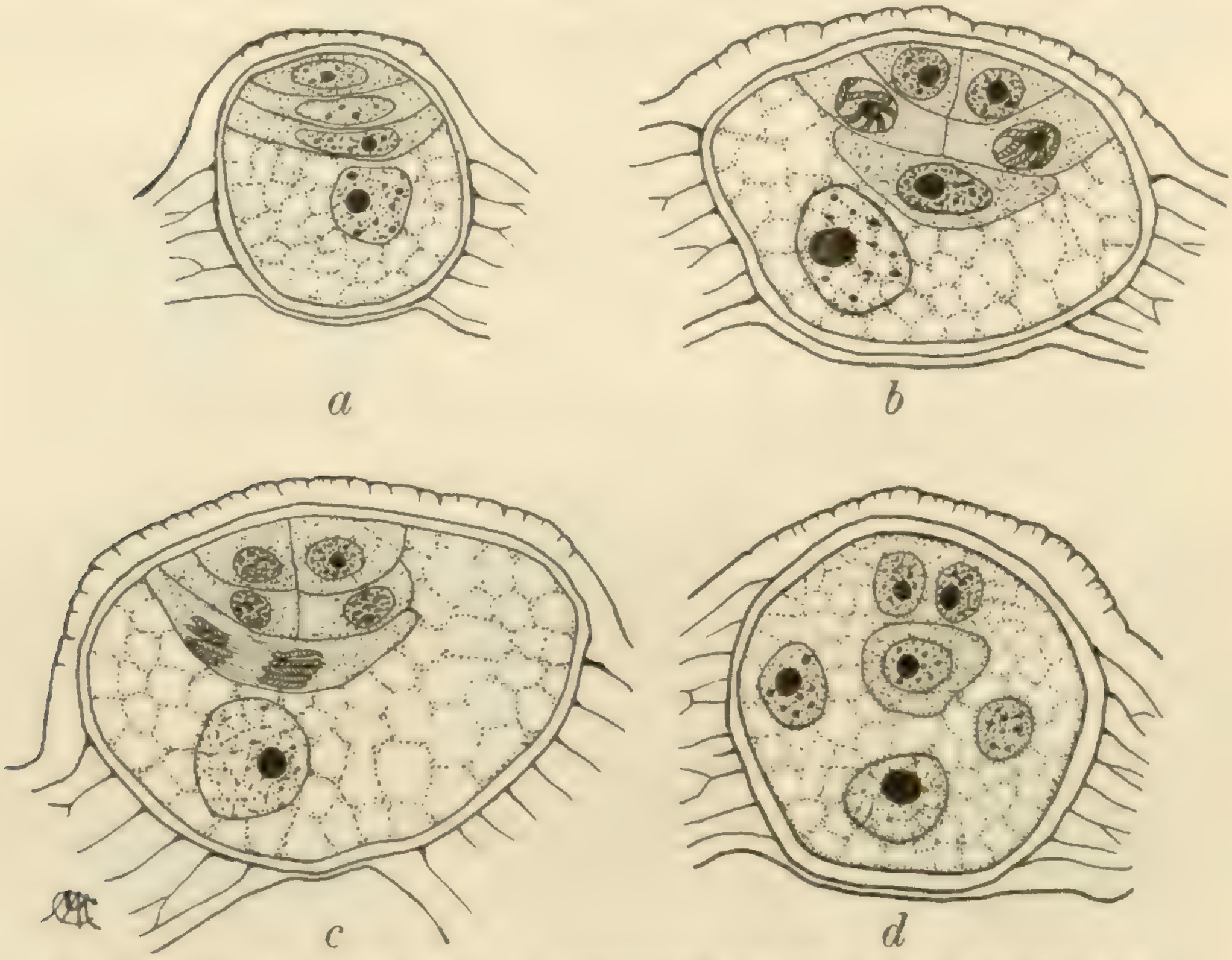


FIG. 2.— *Podocarpus polystachya*. *a*, Generative cell cut off. *b*, Anticlinal divisions of the two original prothallial cells. *c*, Mitosis in the first division of the generative cell. *d*, Nuclei of prothallial cells floating free in the cytoplasm of the pollen grain. × 925.

of the microspore and subsequently in the second prothallial cell. Contrary to the statements of Coker[2] in regard to *P. coriacea*, where a similar but less well marked condition has been described as a probable abnormality due to artificial conditions, anticlinal divisions of the prothallial cells are not initiated by direct division of the nucleus but by true mitosis. In the cells derived from

[1] Thomson, R. B. The Araucarieæ — a 'Proto-Siphonogamic' method of Fertilization. Science N. S. **25**: 271, 272. 1907.

[2] Coker, W. C. Notes on the gametophytes and embryo of Podocarpus. Botan. Gazette **33**: 89–107. pls. 5–7. 1902.

the second prothallial cell in *b* figure 2, the nuclei are still in the spireme condition. Occasionally anticlinal divisions occur in the generative cell as in the prothallial rudiments. One such case is represented in *c* figure 2, which is an obvious and clear mitosis. Usually however in *P. polystachya* such divisions of the generative cell do not occur, although they are exceedingly common in some of the other species which we have had the opportunity of studying. At about this time the prothallial cells lose their walls; and their nuclei, floating freely in the cavity of the microspore, are no

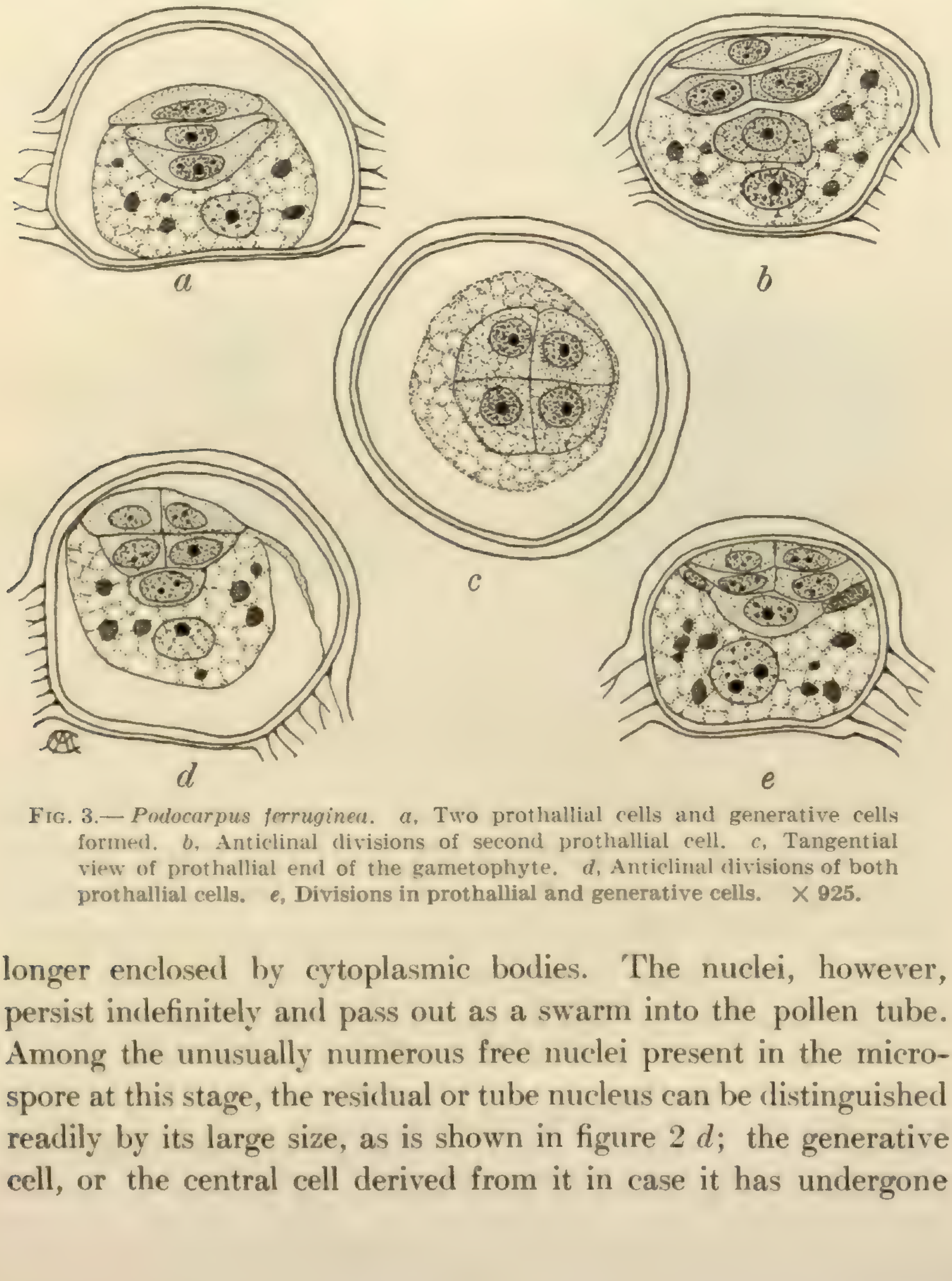


FIG. 3.— *Podocarpus ferruginea*. *a*, Two prothallial cells and generative cells formed. *b*, Anticlinal divisions of second prothallial cell. *c*, Tangential view of prothallial end of the gametophyte. *d*, Anticlinal divisions of both prothallial cells. *e*, Divisions in prothallial and generative cells. × 925.

longer enclosed by cytoplasmic bodies. The nuclei, however, persist indefinitely and pass out as a swarm into the pollen tube. Among the unusually numerous free nuclei present in the microspore at this stage, the residual or tube nucleus can be distinguished readily by its large size, as is shown in figure 2 *d*; the generative cell, or the central cell derived from it in case it has undergone

anticlinal divisions previous to being set free from the prothallial complex, always retains its protoplasmic body as is generally the case in other Gymnosperms, and thus cannot be confused with any of the other contents of the microspore in the condition which immediately precedes anthesis.

In *Podocarpus ferruginea* from New Zealand, material of which we owe to the kindness of Dr. Cockayne, the earlier stages are not so well represented as in the species described above, but so far as they have been followed they present no essential deviation from the course of events in *P. polystachya*. *A* figure 3, represents the abietineous stage of development in this species. The preservation is even less good than that of the Podocarpus already described, and the protoplasm has shrunken from the microspore membrane. In *b* figure 3, is shown a fully developed grain, in which only one of the prothallial cells has undergone division. The generative cell in this case is also free from divisions, although it has rounded off and is almost ready to be set free from the cavity of the microspore. *C* figure 3, presents a tangential view of the first prothallial rudiment, which in this case has undergone two anticlinal divisions, so that four cells have resulted. *D* figure 3, presents a longitudinal section through the air chambers and shows anticlinal divisions in both of the prothallial cells. *E* figure 3, shows a similar condition in the prothallial rudiments; but in this case there are two lateral derivatives of the generative cell. The latter are very small in size compared with the central cell of the generative complex and with the derivatives of the prothallial rudiments.

As is represented in figures 3 and 4, starch is commonly found in the pollen grains, especially in the younger stages, though its presence is by no means constant. A similar feature has been noticed by Coker in the article cited above.

A figure 4, shows the structure of a ripe pollen grain in *P. dacrydioides*, from material sent us by Dr. Cockayne. The conditions are identical with those shown in *e* figure 3, representing *P. ferruginea*.

B figure 4, shows the gametophytic development in a probably mature microspore of *Dacrydium Bidwillii*, another representative of the Podocarpineæ. The material in this case proved to be

very badly preserved. Dacrydium is distinguished from Podocarpus by the transverse striations of the thickened posterior wall of its microspore. In the species of Dacrydium which we have examined more than two prothallial cells are present, but the derivatives of the prothallial rudiments do not seem to be as numerous as they are in Podocarpus, where there may apparently be as many as eight present (*P. ferruginea*).

Through the kindness of Dr. Cockayne we have had the opportunity of comparing the microgametophytic development of Podocarpus and Dacrydium with that presented in Agathis, probably the more ancient of the two living genera of the Arau-

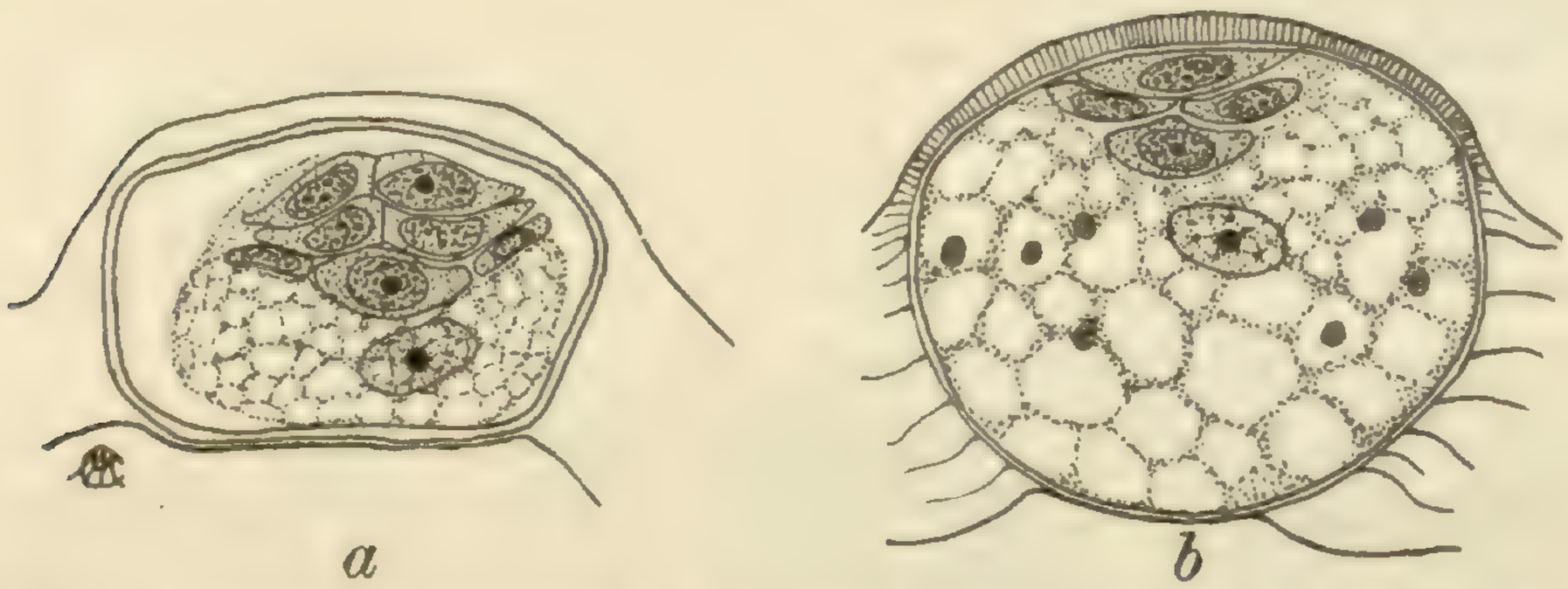


FIG. 4.— *a Podocarpus dacrydioides.* Divisions of prothallial and generative cells. *b, Dacrydium Bidwillii.* The second prothallial cell has divided. × 925.

carineæ. In our material of Agathis the protoplasm is unfortunately very much shrunken, possibly on account of the small amount of alcohol in which it was preserved, but this fortunately does not interfere with the understanding of the general conditions present in the microgametophyte. In *b* figure 5, is shown an apparently mature microspore. We cannot however speak with certainty on this point, since none of the microsporophylls in our possession have shed their pollen. It is to be noted that the conditions present in this figure closely resemble those depicted in *b* figure 2, and *d* figure 3. In other words there are subsequent anticlinal divisions present in the two prothallial rudiments which are originally laid down as they are in the Abietineæ. *A* figure 5, resembles *b* closely and differs in the fact that only one of the prothallial rudiments has become divided. In *c* figure 5, is shown a tangential view of one of the prothallial cells. There have obviously been two anticlinal divisions in this case.

It is apparent from the foregoing paragraphs that in two genera of the Podocarpineæ there are unusually numerous prothallial cells present in the microspore, which are derived by the subsequent anticlinal divisions of the two primitive prothallial cells. That these features are perfectly normal ones in the Podocarpineæ is made clear by the fact that all our material is from plants grown in their native habitat and presumably under natural conditions.

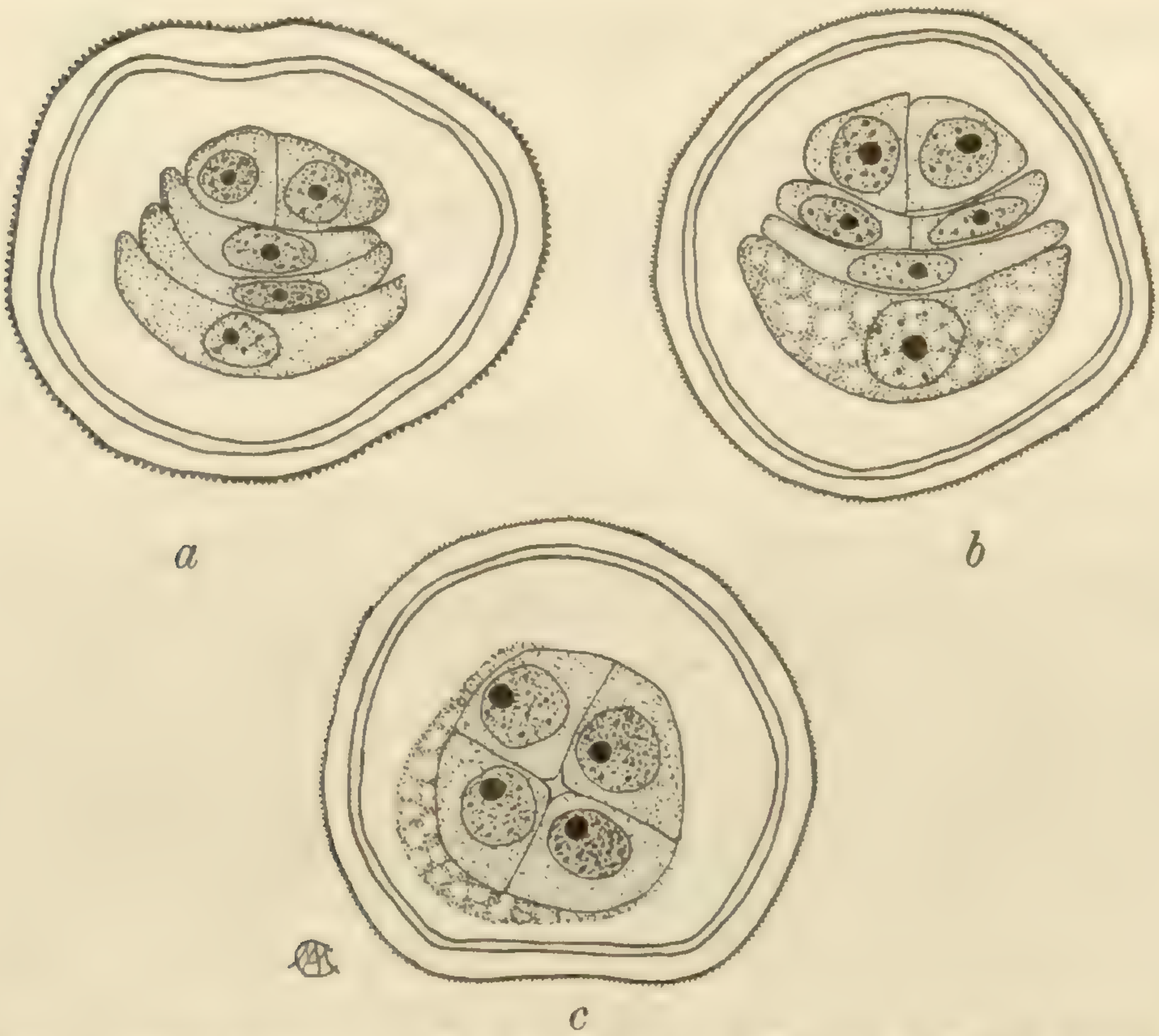


FIG. 5.— *Agathis australis*. *a*, The divided first prothallial cell, undivided second prothallial cell, generative cell, and tube nucleus. *b*, The same, but the second prothallial cell has also divided. *c*, Tangential view of the prothallial end of the gametophyte. × 925.

These features are further paralleled by the conditions presented by the microspore of the araucarian genus Agathis. The question here arises if we are to regard the rich prothallial endowment of the Podocarpineæ as the retention of a feature possessed by the ancestral Coniferales or as a recent cenogenetic adaptation, which has arisen at a later stage of evolution. This question can only be answered by a consideration of the microgametophytic conditions found in the Gymnosperms in general, particularly the more ancient of those still living. In the primitive zoidogamous

Cycads and Ginkgo there are one or two prothallial cells present. The generative cell undergoes only a tangential or periclinal division in connection with the formation of the stalk cell and antheridial cell. The antheridial cell in both the Cycadales and Ginkgoales gives rise to two spermatocytes, the mother cells of antherozoids. In the Abietineæ, which we know from the evidence of the fossil remains extend very far back geologically in forms allied to Pinus, there are two evanescent prothallial cells present in the mature microgametophyte, and a generative cell which as in the zoidogamous Gymnosperms gives rise to stalk and antheridial cells by periclinal division. The antheridial cell in turn gives rise to two cells which are to be regarded as the homologues of the two spermatocytes of the Cycadales and Ginkgoales. In the Araucarineæ, so far as our knowledge goes, there are formed at first two prothallial cells, which may subsequently undergo more or less numerous anticlinal and possibly also periclinal divisions. The final history of the generative cell is obscure, but it is to be inferred from the brief summary of Thomson (*loc. cit.*) that the antheridial cell of the Araucarineæ does not divide into two as in the Abietineæ and the ancient zoidogamous Gymnosperms. In the Araucarineæ there is a further remarkable feature in that the pollen grain does not reach the micropyle of the ovule as in the other Coniferales and all other known Gymnosperms living or fossil; but is deposited on some part of the ovuliferous scale or megasporophyll (on the 'ligule' in Araucaria) thence sending a pollen tube down to the ovule, in a manner analogous to that obtaining in the Angiosperms. Thomson, adopting the prevailing hypothesis that the Araucarineæ are the most primitive Coniferales, designates this peculiar mode of fertilization as primitive or 'prosiphonogamic.'

This view presents some difficulties, for if the quasi-angiospermous method of fertilization found in the Araucarineæ is 'primitive' it is difficult to see why such a method is entirely absent in the older gymnospermous series, the Pteridospermæ, Cordaitales and Ginkgoales, or being ancestral for the Coniferales is entirely lost in the coniferous families other than the Araucarineæ, which have moreover a method of pollination resembling closely that of the older Gymnosperms in that the microspores are received through the micropyle. The reported presence of only a single

sperm-cell in the Araucarineæ supplies another argument against their being more primitive than the other Coniferales. Their superior antiquity further does not rest on any sound palæontological basis, for so competent an authority as Schenk (Zittel's Handbuch) remarks that if more abundant and more ancient geological occurrence were to be considered as a criterion of antiquity, the Araucarineæ must yield place to the Taxodineæ. It appears not unlikely, especially in view of observations made by one of us on Mesozoic Coniferales, shortly to be published, that the 'protosiphonogamic' method of fertilization which is the interesting discovery of Mr. Thomson, is correlated with the proliferation of the prothallial cells in the Araucarineæ, since the greater length of pollen tube, in the absence of any special conductive tissue such as is found in the Angiosperms, calls for a greater development of prothallial tissue. The failure of the pollen to reach the micropyle, on the other hand, may have been due to the unfavorable influence of drought upon the fluid secretion which in other Conifers floats the pollen to the micropyle.

Turning from the Araucarineæ to the Podocarpineæ, we find very similar conditions in regard to the prothallial proliferations. The plan of prothallial development here as in the Abietineæ and Araucarineæ involves two prothallial cells, but as in the Araucarineæ these have apparently undergone cenogenetic proliferation. That this is the true view of the matter is rendered more probable by the fact that even the generative cell may be affected by the process of proliferation, as in *Podocarpus polystachya*, *P. ferruginea* and *P. dacrydioides*, described above. There is certainly no reason from our knowledge of the older and zoidogamous Gymnosperms to regard the anticlinal proliferation of the antheridial cell as a primitive feature, since so far as our present information goes such a phenomenon is quite absent here. Further whatever prejudice there may exist in favor of the Araucarineæ being a primitive family of Conifers, there can be none in favor of a like view in the case of the Podocarpineæ. The development of the microgametophyte in the case of the Podocarpineæ as here described only serves to strengthen the opinion already expressed by Coker (*op. cit.*) and Thomson[1] that they are not

[1] Thomson, R. B. The megaspore-membrane of the Gymnosperms. Univ. of Toronto Studies, Biological Series No. 4. 1905.

very remotely connected with the Abietineæ. Their peculiar prothallial developments represent an apparently cenogenetic superaddition to the primitive type of coniferous microgametophyte found in the Abietineæ. If this view be taken of the position of the Podocarpineæ, it may well be extended to the Araucarineæ which present a similar microgametophytic development, although it would take us too far afield and would involve the discussion of yet unpublished data in regard to living and fossil Coniferales, to defend that proposition in the present connection.

SUMMARY

1. The Podocarpineæ as represented by the genera Podocarpus and Dacrydium are characterized by a proliferation of the two original prothallial cells through more or less numerous anticlinal divisions.

2. The anticlinal proliferation of the prothallial cells in some cases is accompanied by a similar proliferation of the generative cell, an abnormality which appears to have been described in no other Gymnosperms.

3. Similar proliferation of the two original prothallial cells has been observed in the araucarian genus Agathis.

4. The proliferation of the two prothallial cells in the Podocarpineæ and Araucarineæ and the proliferation of the generative cell in certain species of Podocarpus, cannot be regarded as a primitive feature.

5. The ground plan of microgametophytic development found in the Podocarpineæ and Araucarineæ points to their derivation from an ancestral stock allied to the Abietineæ.

6. Since the Podocarpineæ and Araucarineæ present many features of similarity in general habit, in geographical distribution, in the organization of their megasporophylls, and the development of their microgametophytes, it seems not improbable that they are somewhat more nearly allied than has been supposed.

HARVARD UNIVERSITY.

THE PROBLEM OF COLOR VISION

JOHN M. DANE

The problem of color vision is one of the most intricate which the biologist is asked to solve. The following paragraphs are intended to indicate the several methods which are being employed for its solution, together with some of the results thus far obtained. The anatomy of color vision will be considered first; then in turn its physiology and its development; and finally, the abnormal conditions of color blindness, together with the theories of normal vision to which they have given rise.

Anatomy. The mechanism of color vision is lodged in the rod and the cone cells. A ray of light, after passing through the lens of the eye and its vitreous body, penetrates several layers of the retina, thus arriving at the proximal ends of the elongated rod and cone cells. These cells are arranged in a single row. The light traverses the length of the cells to their distal ends which it stimulates. The rod and cone cells project against a single layer of heavily pigmented cells, the *stratum pigmenti retinae* (Fig. 1, S. P.). These have non-retractile processes which are found between the rods and the cones. The pigment fuscin, in the form of elongated or crystalloid granules, migrates into these processes when the eye is illuminated; in the dark it is withdrawn into the cell body.

Every rod cell consists of a rod, a rod fiber, and a nucleus, arranged as shown in Fig. 1, A. A rod, which is from 40 to 50 μ long and 1.5 to 2 μ in diameter, consists of a doubly refractive, lustrous *outer segment*, and a singly refractive, finely granular *inner segment*. In serum or dilute osmic acid the outer segment breaks into a series of regular transverse discs which are believed to indicate a stratified structure in the living rods. Visual purple is a pigment which occurs only in the outer segments of the rods.

It bleaches rapidly in the light, but (unless the pigmented stratum has been removed experimentally) it is soon restored in the dark. Light thus appears to incite chemical processes in the outer segments of the rods. The inner segments are sometimes described as having a longitudinally fibrillar structure in their outer portions. The opposite ends pass rather abruptly into the very slender rod fibers. Each fiber somewhere in its course expands to enclose the nucleus, and finally terminates in a pyriform enlargement. The nucleus in preserved specimens may have its chromatin arranged in a few broad transverse bands.

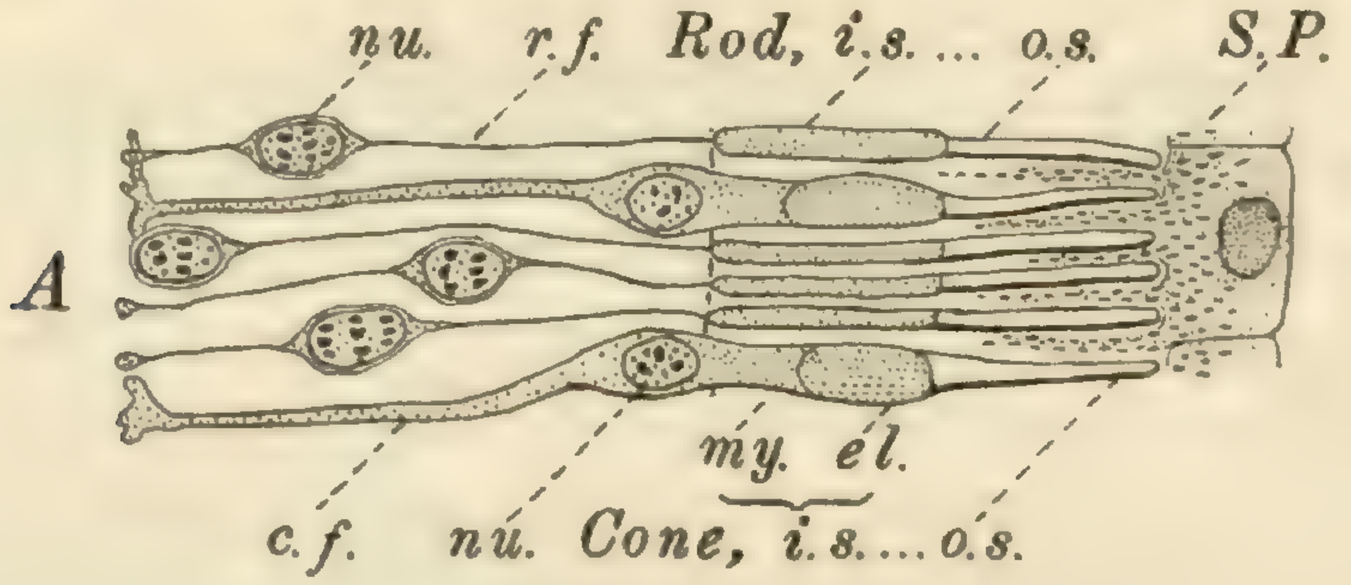
Every cone cell consists of a cone, a cone fiber, and a nucleus. The cones like the rods are divisible into outer and inner segments. The outer segment is usually shorter than that of the rod (12 μ) and tapers somewhat to its rounded extremity. It never contains visual purple, but otherwise, as for example in breaking into transverse discs, it resembles the outer segment of the rod. The inner cone segment bulges like the body of a flask. It is divided into an outer, longitudinally fibrillar, *ellipsoid* portion, and an inner contractile *myoid* portion. The non-contractile ellipsoid is said to become strongly eosinophilic in the dark. Because of the myoid substance the cones, unlike the rods, may alter their length. The contractility is said to be less in man than in the pig, and less in the latter than in some amphibia and fishes where the myoid segment is reported to shorten from 50 μ to 5 μ. The nuclei are found in a mass of protoplasm near the base of the cone; beyond the nucleus the protoplasm forms a cone fiber which is thicker than that of a rod and which ends in a branched and expanded base.

The stimuli received by the outer segments of the rods and cones are transmitted through their fibers to the nerve cells of the retina, and thence to the brain. A single retinal nerve cell receives the stimuli from several rods and cones.

Since rods and cones are believed to have different relations to the perception of color their distribution in man and other animals should be significant. In the peripheral portion of the human retina rods are in excess, so that in sections three or four rods appear between every two cones. Near the depression or *fovea* where vision is most acute, rods and cones are equally abundant,

and in the fovea itself only cones are found. These cones, however, are strikingly rod-like in form, and greatly exceed the rods in length (Fig. 1, B). Slender cones are also found in the thickened *area centralis* which in many mammals replaces the human fovea.

In the ape, horse, pig, cow, sheep, and dog the rods and cones are similar to those of man. In rodents which avoid the light the cones are "very small and hard to detect since their inner segments scarcely differ from those of the rods, from which they may be distinguished by their much shorter outer segment. M.



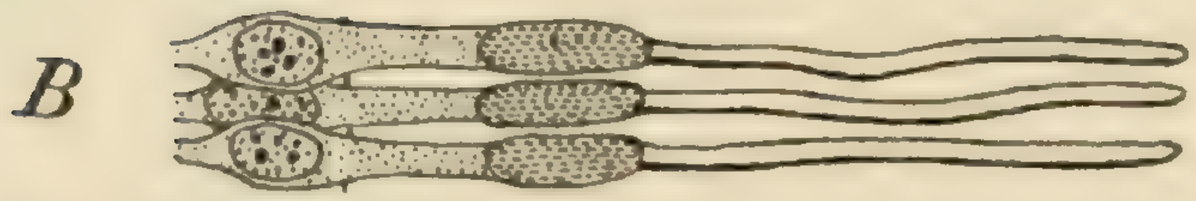


FIG. 1.— *A*, diagram of human rod cells and cone cells from the equatorial part of the retina. *B*, cone cells from the fovea, drawn on the same scale.

Schultze at first questioned the existence of cones in the mouse, guinea pig, mole, hedgehog, and bat. The cat undoubtedly has cones but they are small, slender, and except in the *area*, infrequent."[1] Birds have a single or double fovea, like that of man. Cones are small but very numerous, and in their inner segments they often contain a drop of oily substance, either colorless or various shades of yellow, green or red. Presumably these drops which are absent from the rods and some of the cones, exert an important influence upon color perception. In owls the bright colored drops are lacking and the cones are said to be fewer. Some reptiles have foveæ; two kinds of visual cells are reported, neither of which resembles the mammalian rods. M. Schultze

[1] The quotation, and much of this account of the retina, is from von Ebner's resumé in Koelliker's *Handbuch der Gewebelehre*, 1902, vol. 3, p. 818–832.

believed that reptiles have only cones. In fishes and amphibia, both rods and cones occur; in some sharks, rays, and eels, however, the cones so resemble rods that they may be overlooked. Whether or not deep sea fishes are without cones is apparently unknown. In the various groups of animals the rods and the cones each present modifications of structure, with which as yet physiological observations have not been correlated.

Physiology. The physiology of color vision is the study of the functions of the rod and the cone cells. In passing from a bright to a very dim illumination one experiences a momentary blindness; after becoming accustomed to the darkness, a modified form of vision is regained. In this *twilight vision* the fovea is far less sensitive to light than the more peripheral parts of the retina. Moreover all objects appear in shades of gray. The spectrum is bright but colorless, and its brightest part has shifted from the yellow portion toward the blue. Von Kries has explained these facts by assuming that the cones are the agents of day vision, and the rods of twilight vision.[1] Cones, exclusively, occur in the fovea where day vision is most acute; and rods predominate where twilight vision is at its best. The fluctuations in the visual purple of the rods show that they respond to the varying intensities of dim light, and this purple is known to desintegrate most rapidly in green light which appears brightest in twilight vision. Whether or not the bleached rods are active in day vision has not been determined.

It is probable that all cones do not respond to color stimuli. In the peripheral portion of the retina there is a partially color-blind region where red and green cannot be distinguished from one another; and the outermost portion of the retina is always totally color blind. Since cones occur in these areas they also must be color blind. From these considerations it is reasonably assumed that, in human vision, the ability to perceive colors depends upon the differentiation of certain of the cones.

Since at the present time the nature of vision cannot be determined by the microscopic examination of the retina, and since a very efficient vision may exist without color perception, it may

[1] Von Kries presents this *Duplizitätstheorie* in Nagel's *Handbuch der Physiologie*, 1904, vol. 3, p. 168–193.

fairly be questioned whether the lower animals are capable of color vision. The biological importance of this problem is very great, since prevalent theories of the development of the colors of flowers, and the bright plumage of male birds, assume a color perception in insects and female birds essentially like that in man. To learn what a bee actually sees has been thought impossible since it requires that one should possess the nervous system of an insect and still remain a man.

There is a large literature dealing with the distinctions which the lower animals make between various colors, but the factor of intensity or brightness has seldom been satisfactorily eliminated. The trout fisherman is confident that one fish, at least, discriminates colors with precision. Careful experiments with the chub, by feeding it from colored forceps and taking certain precautions to eliminate brightness, indicate that the chub distinguishes red from green and from blue.[1]

Nagel, who is convinced that the phenomena of mimicry and warning colors demand color vision in animals, experimented with the dog. After taking precautions to eliminate brightness, he proved that the dog perceived the difference between red and blue, blue and green, and red and green.[2]

Kinnaman tested the monkey, *Macacus rhesus*. Its food was placed in one of six receptacles, precisely alike except that each was of a different color. When the monkey had learned to choose correctly the food-containing glass, a different color was selected. Thus the monkey learned to proceed at once to the receptacle with food, whether it was blue, yellow, red or green. It was tested also with a black and light gray glass. Having learned that the food was in the former, successively darker grays were substituted for the empty one. The percentage of wrong choices increased and it was found that grays were confused which the human eye can distinguish with perfect ease and certainty. Kinnaman concludes that "there can be no doubt that monkeys per-

[1] Washburn, M. F. and Bentley, I. M. The establishment of an association involving color discrimination in the creek chub. *Journ. of Comp. Neur.*, 1906, vol. 16, p. 113–125.

[2] Himstedt, F., and Nagel, W. Versuche über die Reizwirkung verschiedener Strahlarten auf Menschen- und Tieraugen, *Festschrift der Albert-Ludwigs-Universität* in Freiburg, 1902.

ceive colors." Two colors of equal brightness are distinguished better than two grays of equal brightness; and though the brightnesses are the same, colors may be distinguished from grays.[1]

In the dancing mouse, however, the cones of which are at least very rod-like, Yerkes has recently found that color vision is extremely poor. There is some evidence of discrimination of red and green, and of red and blue, but none whatever of blue and green. Apparently such visual guidance as is received results from differences in brightness. The mouse discriminates blacks grays, and whites.[2]

Because of the inherent difficulties in the investigation of color vision in the lower animals, comprehensive results have not yet been obtained, but the newer methods promise notable discoveries.

Development. Since color vision is a complex differentiation, it might be expected that in the course of development, an individual should successively pass through the simpler stages by which it was acquired. Anatomically it has been shown that the retinal layers first become distinct at the center of the retinal cup, and that the differentiation of the retinal cells decreases from the center toward the periphery. In the chick it is said that the cone nuclei may be identified at an earlier stage than the rod nuclei,[3] but it is not generally recognized that one form of visual cell precedes the other.

The development of color vision has been theoretically considered by Mrs. Ladd Franklin.[4] Her theory assumes that the colorless sensations, white, gray and black, are caused by a primitive photo-chemical substance called the gray substance, which is composed of numerous gray molecules.

These gray molecules, which persist in their primitive state only in the rods, upon disassociation furnish us with the gray sensa-

[1] Kinnaman, A. J. Mental life of two *Macacus rhesus* monkeys in captivity. *Amer. Journ. of Psych.*, 1902, vol. 13, p. 98–148.

[2] Yerkes, R. M. The sense of vision in the dancing mouse. *Journ. of Comp. Neur.*, 1907, vol. 17, p. 194.

[3] Weysse, A. W., and Burgess, W. S. Histogenesis of the retina. *Am. Nat.*, 1906, vol. 40, p. 611–634.

[4] Franklin, C. L. On theories of light sensation. *Mind*, 1893, N. S. vol. 2, p. 473–489.

tions. In the cones the gray molecules have undergone a development such that a certain portion only of the molecule becomes disassociated by the action of light of a given color.

The differentiation of the primitive gray molecule is supposed to have taken place in three stages (Fig. 2). The first stage is represented by the simple, primitive gray molecule, so constructed that it is disintegrated by light of any color, thus producing a gray or white sensation. In the second stage the molecule is more complex and contains two groupings, the disassociation of one of which gives the sensation of yellow and the disassociation of the other gives blue. The simultaneous disassociation of both gives white. This stage persists in the peripheral portion of the retina where neither green nor red can be perceived as such. In the third stage the yellow grouping is divided to form two new combinations, the disassociation of one of which produces the sensation of green and the other the sensation of red. If the red and green groupings are disassociated together the resulting sensation is yellow; whereas the simultaneous disassociation of the red, green, and blue groupings produces the white sensation.

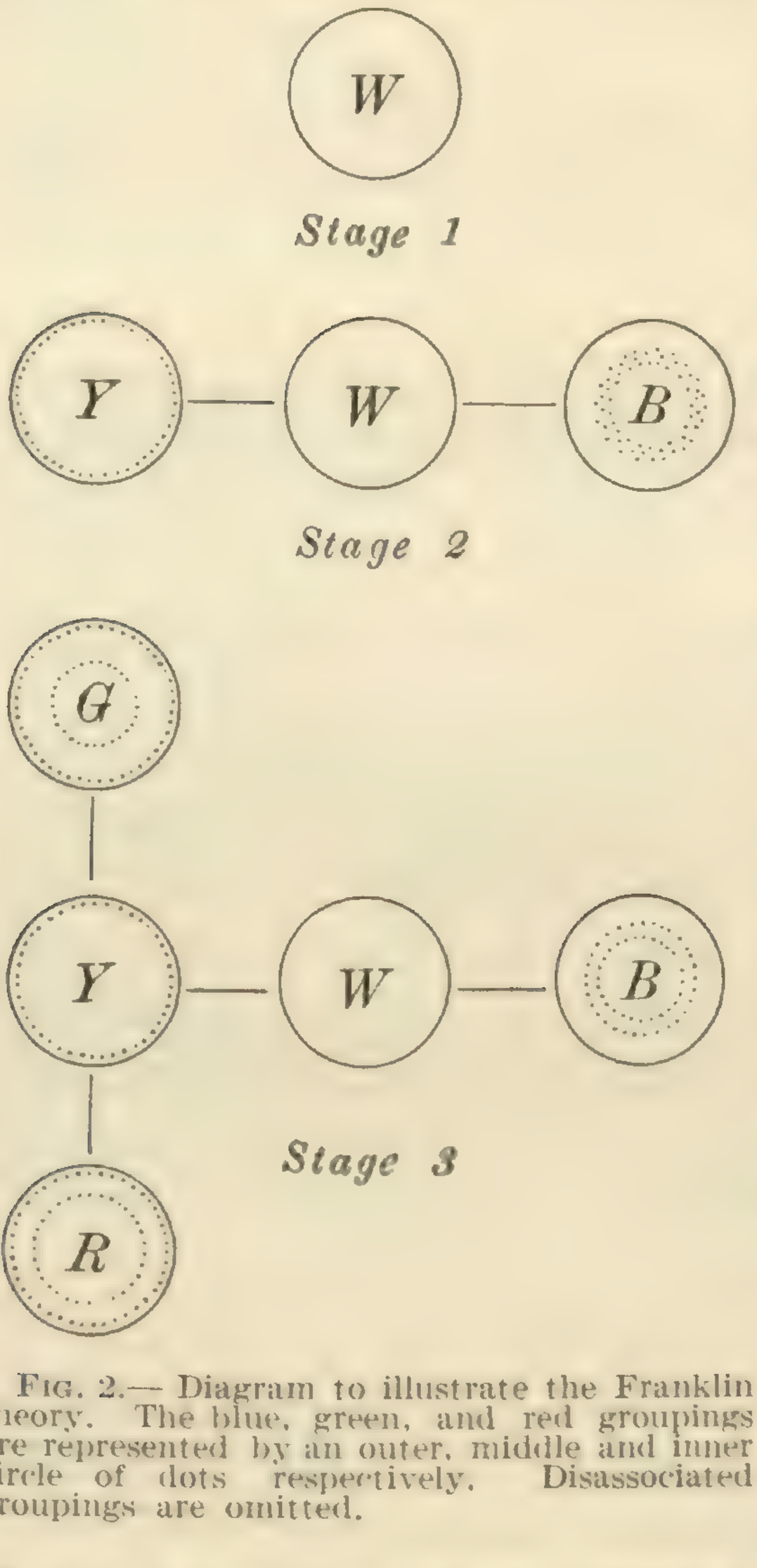


FIG. 2.— Diagram to illustrate the Franklin theory. The blue, green, and red groupings are represented by an outer, middle and inner circle of dots respectively. Disassociated groupings are omitted.

Schenck [1] has somewhat extended this theory by describing the development of the primitive gray molecule. Since in twilight

[1] Schenck, F. Über die physiologischen Grundlagen des Farbensinns. *Sitz.-ber. d. Gesell. d. ges. Naturw. z. Marburg.* 1907. Jahrg. 1906, p. 133–164.

vision the red end of the spectrum is lost, and the green-blue portion is its brightest part, he considers that the photo-chemical substance of the rods is attuned only to the green-blue light, which is perceived as colorless. Later this photo-chemical substance becomes sensitized in two stages, first to include the green-yellow, and then the yellow-red, which however are still perceived as colorless light. Thus a gray molecule like that of Mrs. Franklin's first stage is constructed. It occurs in the color blind peripheral cones. The formation of color-reacting groupings in the partly sensitized gray molecule leads, according to Schenck, to those forms of human vision in which the red end of the spectrum is shortened.

Observations upon the color perception of young children do not support these developmental theories. Holden and Bosse [1] tested two hundred children by placing before them square pieces of colored paper attached to a gray background of similar brightness. If the child made an effort to grasp the square, its color must have been perceived. It was found that the average child would react to all colors by the tenth month, the red end of the spectrum causing response a little earlier than the violet end. When ribbons of six spectral colors were placed before children of from seven to twenty-four months, red was selected first; orange or yellow second and third; and green, blue and violet last of all. Nagel [2] showed his child of twenty-eight months each of the spectral colors in varying degrees of brightness, at the same time teaching him their names. Red and green were learned easily, but blue was acquired with greater difficulty than any other color, including violet. Green, violet, and red were preferred; black, yellow, white, gray, and blue had secondary rank. Other experiments with the color perception of children have given different results. It is clear, however, that children are not known to pass from a color blind stage, through one of yellow-blue vision, to a discrimination of all the spectral colors. No race of men now exists in

[1] Holden, W. A. and Bosse, K. K. The order of development of color perception and color preference in the child. *Arch. of Ophth.*, 1900, vol. 29, p. 261–277.

[2] Nagel, W. A. Observations on the color sense of a child. *Journ. of Comp. Neur.*, 1906, vol. 16, p. 217–230.

which any of the colors is unknown; and the notion derived from studying the color terms and references in ancient literature, that man in historic times had a deficient color sense, is not substantiated. It may be that as in children, the red portion of the spectrum was preferred to the blue, but even this is not established.

Color blindness. All the colors which are normally perceived may be produced by combinations of the spectral red, green, and blue. Normal vision is therefore *trichromatic.* Sometimes in trichromatic vision the red end of the spectrum is shortened; in other cases a mixture of red and green, which to normal persons appears pure yellow, may seem tinged with red or green. Thus there are variations in trichromatic vision. Greater abnormalities may take the form of *dichromatic* and *monochromatic* vision. The latter is a rare pathological condition in which all colors are perceived as shades of one; vision therefore is essentially colorless (achromatic), the images obtained being comparable with photographs. In dichromatic vision color perception is so limited that all of the shades perceived may be made by combining two of the spectral colors red, green, and blue; blindness to the third of these colors may be partial or complete. The ordinary color blindness is dichromatic. Forty men and four women per thousand are either wholly unable to perceive certain colors or can recognize them only with difficulty. This defect is usually congenital and hereditary. It may cause so little trouble as to pass undetected until the age of seventy. All attempts to overcome the color blindness by educating the color sense in various ways, have failed.

Since dichromatic color blindness plays so large a part in the theories of normal vision, a portion of Dr. Pole's description of his own case is here inserted. He says,[1] "In the first place we see white and black and their intermediate gray, provided they are free from alloy with other colors, precisely as others do. (Such statements are confirmed by those who are color blind in one eye, the other being normal.) Secondly there are two colors, namely yellow and blue, which also if unalloyed we see, so far as can be ascertained, in the normal manner. But these two are the *only*

[1] Pole, W. Colour blindness in relation to the Homeric expressions for colour. *Nature,* 1878, vol. 18, p. 676–679.

colors of which we have any sensation. It may naturally be asked: Do we not see objects of other colors such as roses, grass, violets, oranges, and so on? The answer is that we do see all these things but that they do not give us the color sensation correctly belonging to them; their colors appear to us as varieties of the other color sensations which we are able to receive. Take for example the color red. A soldier's coat or a stick of sealing wax conveys to me a very positive sensation of color, by which I am perfectly able to identify, in a great number of instances, bodies of this hue. But when I examine more closely what I really see, I am obliged to conclude that it is simply a modification of one of my other sensations, namely yellow. It is in fact a yellow shaded with black or gray, a darkened yellow or yellow brown."

Dichromatic vision occurs in three forms, in two of which red and green are not differentiated from one another. The three forms are named *protanopia*, *deuteranopia*, and *tritanopia* respectively. In protanopia the red end of the spectrum is shortened; that is, a portion which to the normal person is red, appears black. The remainder of the red, the orange, the yellow, and the green appear as successively lighter shades of yellow which, toward the blue, becomes gray or white. This white shades into blue which deepens toward the violet end of the spectrum. In deuteranopia, which is the normal condition of a peripheral zone of the retina, the red of the spectrum is not shortened. Red, orange, yellow and green appear as lighter shades of one color, called red or yellow, and shade into a white or gray band which is a little nearer the red end of the spectrum than the corresponding band of protanopia. Blue is perceived normally. Tritanopia is a rare form in which yellow and blue are not recognized. The spectrum presents red and green portions, separated by a white band in place of the yellow. A dark green is seen in place of blue and the violet end of the spectrum is shortened.

Theories of Color Vision. Certain features of color blindness are ingeniously explained by Hering's theory, illustrated in figure 3. It is supposed that the cones contain a photo-chemical substance which is disassociated by red rays but which is built up by the green rays, giving rise respectively to the sensations of red and green. A second substance is broken down by yellow and built

up by blue light. As shown in the figure, orange is a mixed sensation due to the simultaneous partial destruction of the red-green and the yellow-blue substances. Yellowish green and greenish blue are likewise mixtures, and violet is supposed to combine the partial construction of the yellow-blue with the destruction of the red-green, the latter being indicated by the broken line. There are four pure sensations, red, yellow, green, and blue. Color blindness may be due to the absence or deficiency of the red-green substance (protanopia and deuteranopia, the two forms being varieties of a single type), or to lack of the yellow-blue substance (tritanopia). Hering further considered that there was a white-black substance, built up in darkness to give rise to the sensation

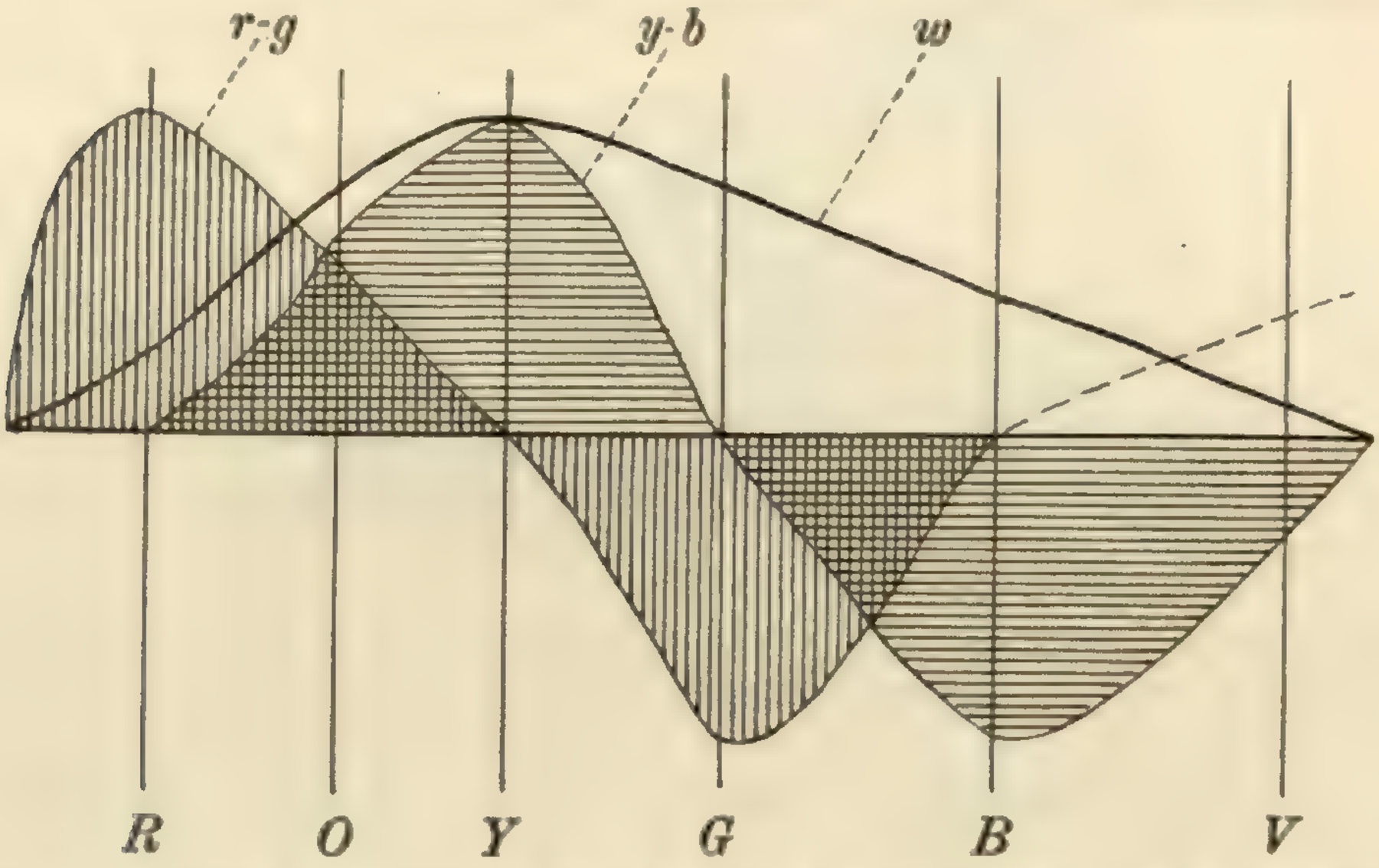


FIG. 3.— Diagram to illustrate Hering's theory of color vision. The red-green substance, *r-g*, is vertically shaded; and the yellow-blue substance, *y-b*, is transversely shaded.

of black, but destroyed in varying degree by different colored lights, thus giving white. In monochromatic vision the retina contains only this white-black substance. The curve *w* of figure 3 shows that the maximum stimulation of white is in the yellow portion of the spectrum. Without considering the difficulties concerning the white-black hypothesis, it may be questioned whether both constructive and destructive chemical processes can produce color sensations of similar nature. Mrs. Franklin considered that her theory was supported by the fact that the color sensations were all chemically destructive. Hering's theory, moreover, calls for four primary color sensations, whereas physi-

cists recognize that only three are necessary. Accordingly the physicist Young proposed a simpler theory antedating that of Hering. It was advocated by Helmholtz, and is generally known as the Young-Helmholtz theory.

According to the Young-Helmholtz theory there are three photochemical substances, red, green, and blue respectively, which are stimulated by the various rays of the spectrum as shown in figure 4. Absence of stimulation produces black, and the simultaneous disassociation of all three yields white. Protanopia is interpreted as red blindness, due to deficiency of the red perceiving substance. Deuteranopia is green blindness, and tritanopia is blue blindness. Since it would appear that the perception of white must be lost

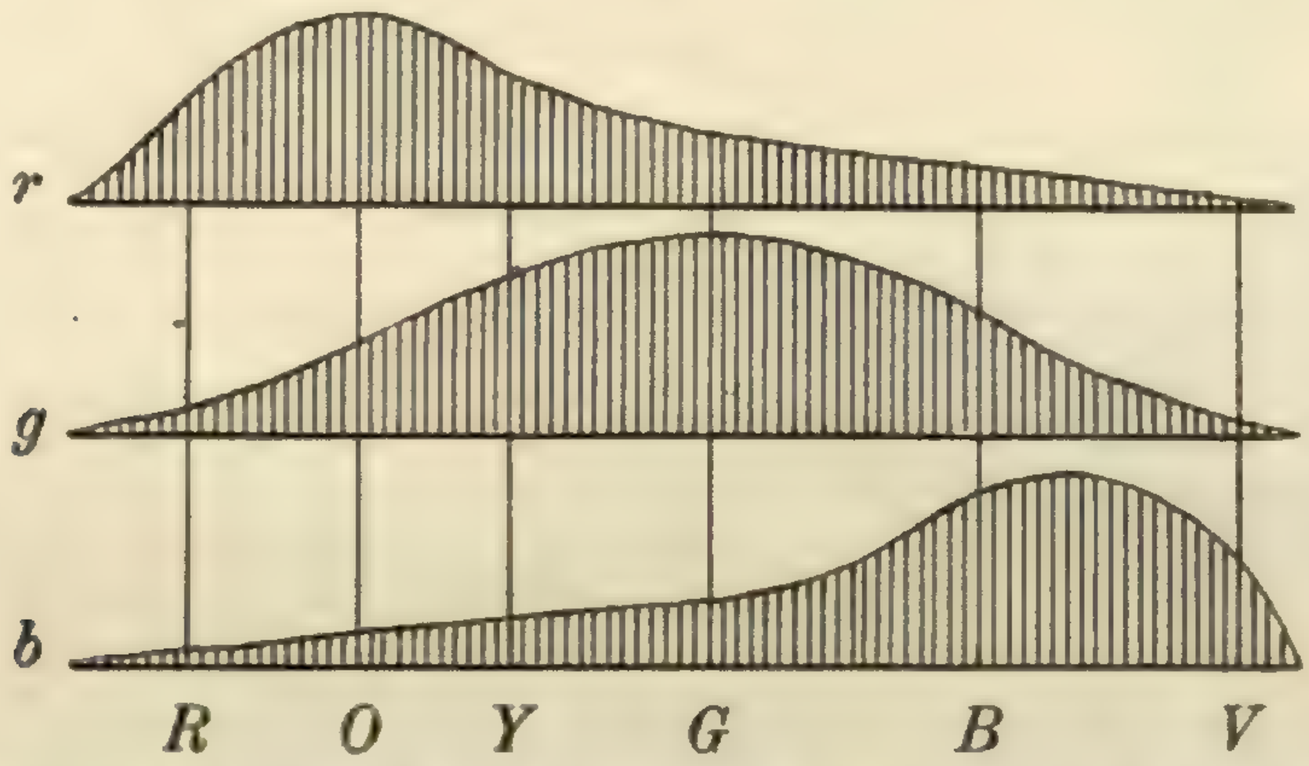


FIG. 4.— Diagram to illustrate the Young-Helmholtz theory. *r*, *g*, *b*, red, green, and blue perceiving substances, respectively.

with the disappearance of one of the three elements, the theory has been variously modified. In protanopia the red and the green substances may be so altered that each responds both to red and green light (Fick), or the red and the green substances may be imperfectly segregated, as assumed by Mrs. Franklin's theory. The close relation between the red and green substances is shown in Koenigs presentation of the Young-Helmholtz theory (Fig. 5). The absence of either would give rise to somewhat similar conditions, such as occur in protanopia and deuteranopia. The figure indicates that in trichromatic vision, the colors from yellow to blue affect all three substances to a certain extent, thus adding a small amount of white to the color sensation. In dichromatic vision the mixing of the two elements yields white. In case the red substance is absent, this white will appear nearer the blue than in case the green is absent; its position is indicated by the

intersection of the blue with the green and red curves respectively. In the absence of the blue substance, the white band is near the yellow. This accords with the observations upon the color blind. The absence of the green substance would not shorten the spectrum, but the lack of the red or blue would cut off their respective ends. All of these features are equally well explained if, instead of the absence of one of the three substances, such a modification of its reaction is assumed as would be illustrated by a lateral shifting of its curve in the diagram. Thus in red blindness the red curve is shifted to cover more closely the territory of the green; in green blindness the green is shifted toward the red; and in blue blindness the blue and green curves are brought together. Thus

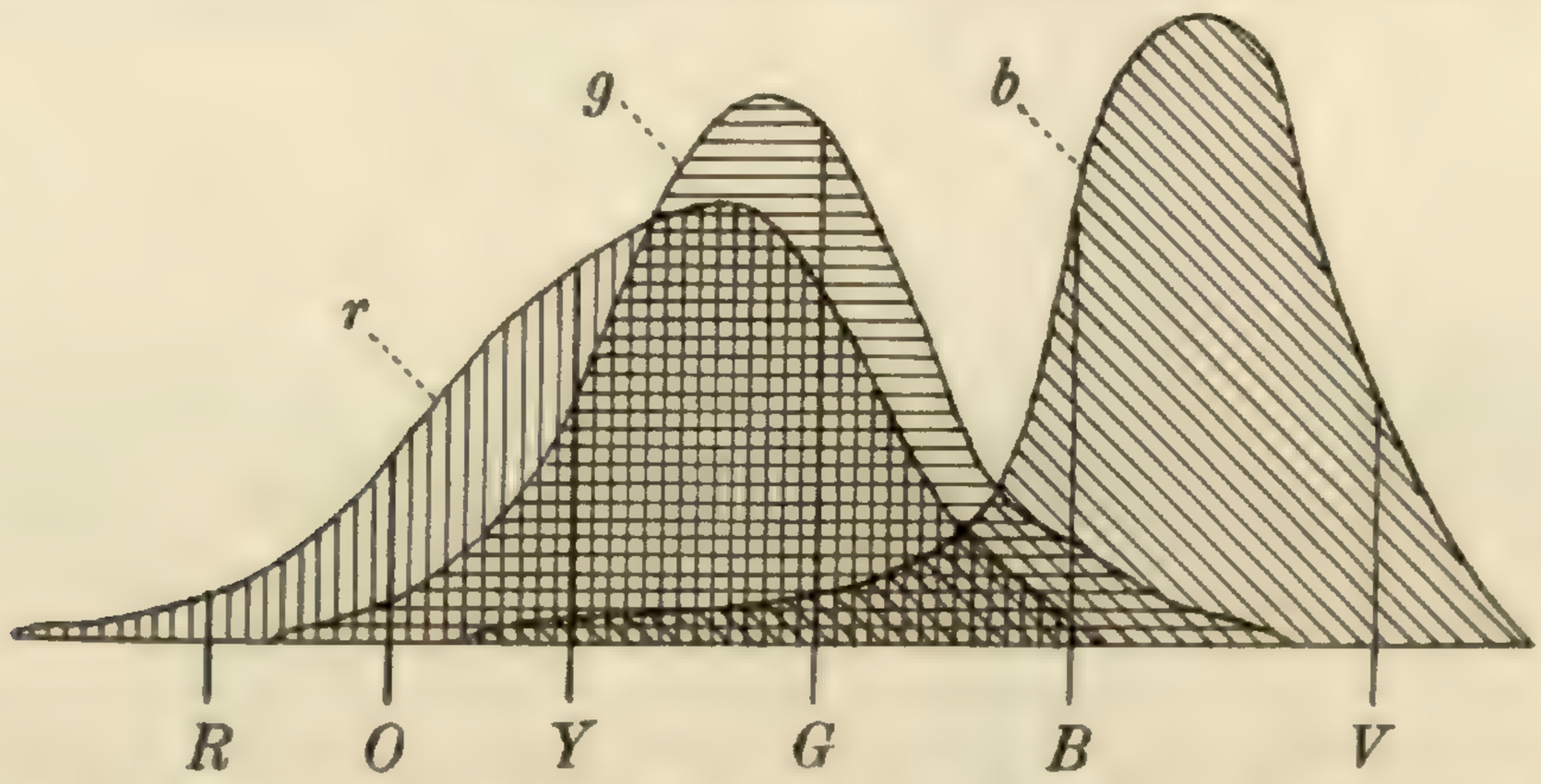


FIG. 5.— A modified diagram of the Young-Helmholtz theory, after Kœnig.

in the color blind all three substances are present but in modified form. Since this modified Young-Helmholtz theory accords so well with observations on color blindness, it is generally considered as the most satisfactory explanation of color vision.

An interesting attempt has been made by Patten to bring this theory into relation with structural elements in the cones.[1] He believes that the visual cells of invertebrates are characterized by a fibrillation which is transverse to the direction of the incident light waves, and that the tendency of the vertebrate rods and cones to separate into transverse discs is evidence of a similar structure. Many hundreds of such fibrils may exist in a rod or cone. They are not supposed to vibrate like tense strings, but

[1] Patten, W. A basis for a theory of color vision. *Am. Nat.*, 1898, vol. 32, p. 833–837.

to act as 'conductors or resonators,' a fact which would not exclude chemical changes resulting in fatigue. The long fibrils respond to the red end of the spectrum and the short ones to the blue. In rods the fibers are of equal length and only monochromatic vision is possible, but in the cones their varying length allows a range of color perception. Any variation in the form or dimensions of the cones would bring about corresponding changes in vision. The increased length of the cones at the fovea provides for a greater power of color discrimination. If the base of a cone were absent or cylindrical it would be red blind.

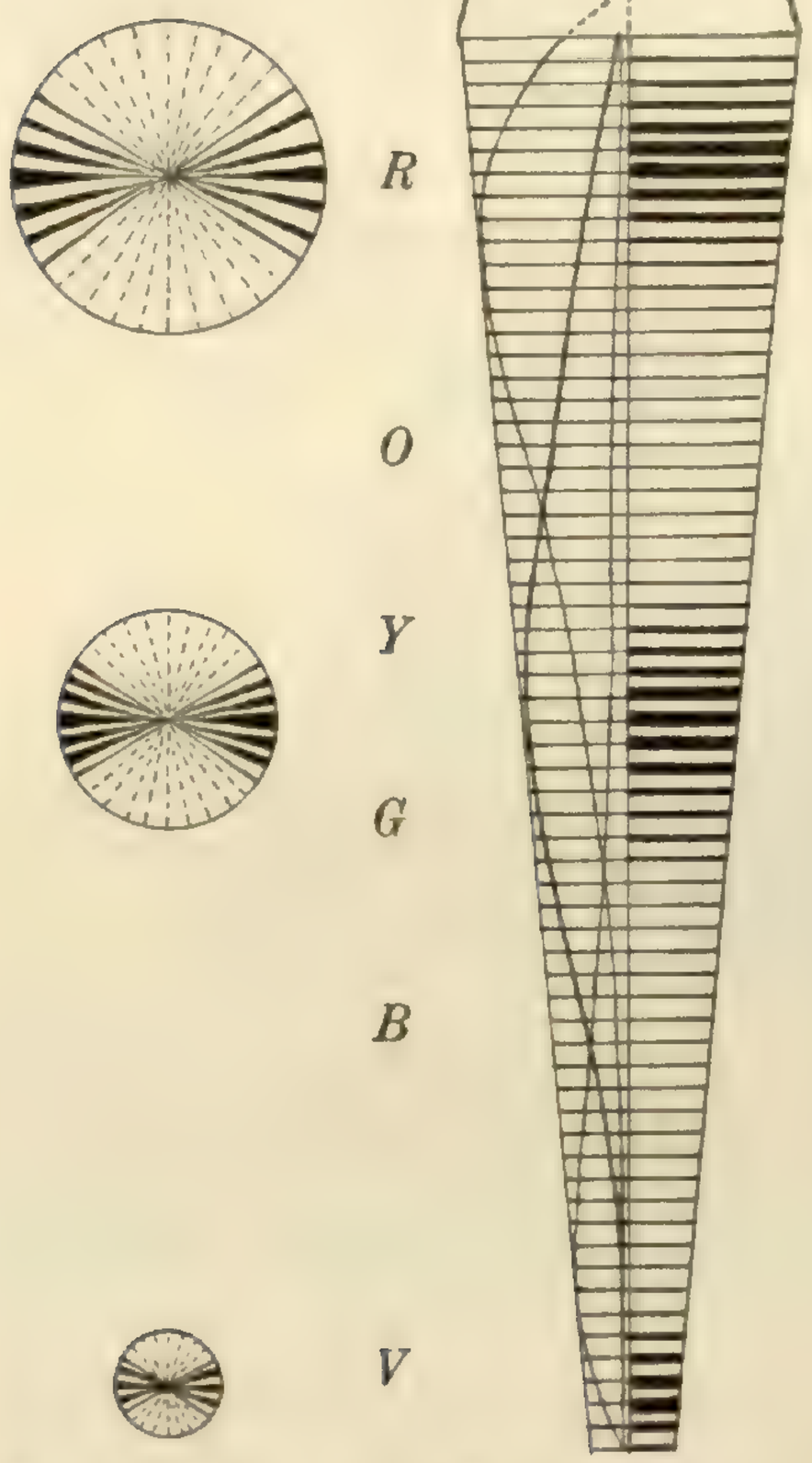


FIG. 6.— Diagram to illustrate the supposed fibrillar structure of human cones, and the way in which various light waves affect them. (Patten.)

This theory is illustrated in figure 6. On the right is the diagram of a cone and its fibrils; the latter radiate from an axial filament, the existence of which has been discussed and denied by other investigators. The fibrils in the right half of the cone are drawn as responding to red, yellowish green, and violet light; the Young-Helmholtz curves are shown on the left. In nonpolarized light all of the fibrils in a transverse section of a cone respond uniformly, but in polarized light only such are effected as are indicated in the cross sections on the left of the figure. Thus the dullness of polarized light is explained. The correctness of this supposition, as Dr. Patten states, will be determined by extensive measurements, much more accurate and detailed than any heretofore made, of the visual elements in all classes of animals.

It will be noted that according to Patten's and Mrs. Franklin's theories the mechanism for reaction to all the colors may exist in a single cone. The Hering theory calls for the reaction to at least

two colors in one cone; but according to the Young-Helmholtz theory, although the three substances could exist in a single cone, each is declared to exist in a cone by itself. This is considered to be strongly in favor of the validity of the Young-Helmholtz theory. Since physiologists find no instance in which different sorts of impulses are conveyed over a given nerve fiber, it is believed that a single cone fiber can transmit only one sort of color sensation. The stimuli of the red, green, and blue cones respectively are supposed to be gathered by separate nerve cells of the retina, and the optic nerve consequently contains certain fibers transmitting only red, green, and blue sensations respectively. The mixing of the sensations, giving rise to the perception of shades and tints, is therefore accomplished in the brain and not in the cones. In an attempt to test this supposition, attention has been called to the perception of the colors of stars. The image of the star is so minute that it would cover but a single cone, but the conclusion that one cone perceives its color is invalidated by the fact that the retina is not sufficiently stationary; the image of the star falls in rapid succession upon several cones which may unite in giving the color perception. Those who believe in the specific energy of the rod and cone fibers dismiss at once several of the theories of color vision. It must be remembered, however, that the separation of the cones into forms responding to red, blue, and green light, with three corresponding sets of nerve cells and fibers to convey these separate stimuli to the brain, does not rest upon anatomical evidence.

PHYSIOLOGICAL LABORATORY
Harvard University

THE BREEDING HABITS OF *AMBLYSTOMA PUNCTATUM* LINN[1]

BERTRAM G. SMITH

On April 9, 1906, in some small ponds in a wood in the vicinity of Ann Arbor, Michigan, Prof. Jacob Reighard discovered what he surmised to be spermatophores of Amblystoma. At his suggestion and under his direction, I undertook the identification and study of these structures.

I. Observations

A. **The Spermatophores.** The spermatophores look like bunches or tufts of snowy-white fungus growing on leaves, twigs, or stalks of grass lying on the bottom of the pond. They invariably occur on a horizontal surface, and are never attached to an erect twig or stalk as is often the case with the eggs of Amblystoma. They are found in water from 6 to 10 inches deep, and 5 to 10 feet from the shore. The spermatophores usually occur in groups of about 40 or 50, but the number is extremely variable, ranging from 1 to 100. Isolated spermatophores are rarely found, though a single one is conspicuous enough to be readily discovered. The spermatophores of each group are scattered over an area of rather more than one square foot. Along the shores of an elliptical pond about 125 feet in length, 25 groups of spermatophores were counted; they were less numerous in three other ponds examined.

The spermatophores (Fig. 1.) resemble those of *Triton* (*Diemyctylus*) *viridescens* as described by Jordan ('91 and '93) rather than the more complicated structures produced by some European forms (Zeller, '05). Each consists of a base and a stalk of clear gelatinous material almost invisible in the water, having the general form of the stump of a tree, this structure is surmounted by a slightly broader cap or tuft of snowy-white felt-like material consisting of spermatozoa with no visible matrix. The material con-

[1] Contributions from the Zoological Laboratory of the University of Michigan, No.

stituting the base must be strongly adhesive when fresh, for the spermatophore is firmly attached to the object on which it is deposited. The cap is usually hemispherical in form, with the convex surface upward; but the material of which it consists often runs down the side of the stalk, or is found projecting in downy tufts like the cotton from an open cotton-boll. In many cases the caps have a frayed appearance, as if they had been disturbed; in occasional specimens the cap of spermatozoa is partly or almost wholly absent. The appearance in the latter case is like that of a spermatophore of *Triton viridescens* from which I have seen the ball of spermatozoa taken up into the cloaca of a female. The dimensions of the complete spermatophore are about as follows:

Height	6–8 mm.
Breadth of base	6–8 mm.
Diameter of stalk near top	2.5–3 mm.
" " cap	3–4 mm.

As compared with some spermatophores of *Triton viridescens* obtained from specimens in captivity, these under discussion are slightly taller, with a smaller base and a stalk of much larger diameter, surmounted by a larger mass of spermatozoa. The spermatophore of *Triton viridescens* has a broad flattened base from the center of which rises a distinctly conical stalk tapering to a very slender spine, at the top of which is attached a small ball of spermatozoa; the spermatophores attributed to Amblystoma are more massive and more nearly cylindrical.

When found on April 9 and 10 the spermatophores were all in good condition, with some slight differences in the freshness of their appearance. In two or three days they became infested with fungus, disintegrated quite rapidly, and in a week very few of them could be found. Had new ones been deposited in the interval, they could readily have been distinguished from the old ones; but no more spermatophores were deposited. Hence it is scarcely possible that the period during which spermatophores are deposited lasts longer than two or three days.

The spermatophores shown in the figure had been attacked by fungus and were beginning to disintegrate when photographed. The base is therefore no longer clear, but on the contrary the whole spermatophore appears white.

Identification. In order to identify the spermatophores, search was made for the parent animals. This resulted in the capture on April 11, of three specimens of *Amblystoma punctatum* Linn. which were found embedded in rotten wood under a stump at the edge of the water of one of the ponds where the spermatophores were numerous. From two of these specimens a few drops of seminal fluid, containing an abundance of spermatozoa, were obtained by stripping; from the third, which proved to be a female,

FIG. 1.— Spermatophores of *Amblystoma punctatum*. Two-thirds natural size, linear reduction.

comparatively few spermatozoa were obtained. The spermatozoa were mounted, stained, and compared with some taken from spermatophores and similarly treated. In structure, size, and staining reactions the two were identical.

Another species, *A. tigrinum* Green, also occurs in the vicinity

of Ann Arbor, and a single example was taken on April 9, in a field several hundred yards distant from the nearest pond where spermatophores were found; but the eggs of the two species are easily distinguishable, and in the case of *A. punctatum* were identified by means of eggs laid in the laboratory. With the exception of one bunch of eggs of *A. tigrinum*, all the eggs found in the pond where spermatophores were observed, were those of *A. punctatum*. With the single exception above noted, the two species have not been known to breed in the same ponds in the vicinity of Ann Arbor.

B. **The Spermatozoa.** The spermatozoon of *Amblystoma punctatum* is extremely long and slender. The head stains well with Delafields' haemotoxylin, the middle-piece less deeply. The tail-piece is bordered on one side by a very delicate undulating membrane. Some of the dimensions are as follows:

Length of acrosome	20 μ
" " head	106 μ
" " middle-piece	14 μ
" " tail-piece	480 μ
Total length	620 μ

The spermatozoon resembles in size and form that of *Triton viridescens*, with which it was compared, but the latter has a middle-piece twice as long, and a more conspicuous undulating membrane.

As compared with the spermatozoon of *Cryptobranchus alleghaniensis* (Smith '06) the sperm of *Amblystoma punctatum* is nearly three times as long, with a proportionally much longer middle-piece; the entire structure is much more slender and thread-like.

In freshly mounted seminal fluid the spermatozoa were seen in active motion. They tend to cling together parallel to each other to form bundles or ringlets, revolving with a circular motion; when so clustered they retain their vitality much longer than when separated. In a dying spermatozoon, long after the shaft has ceased to move, the activity of the undulating membrane continues. It gradually becomes slower until with a high magnification it is possible to follow a trough or a crest without interruption or change of form across the entire field of the microscope. The undulating membrane does not wind about the shaft as in Cryptobranchus, but continues on one side of it. When dead, the sperms are usually

found much convoluted, indicating a greater degree of flexibility than is the case with stouter spermatozoa like those of Cryptobranchus.

Experiments were performed to determine the length of time the spermatophores would retain their vitality in water, hence the interval within which they would have to be taken up by the female. In all the spermatophores examined the spermatozoa were motionless; but since the examination was not made until the evening of April 10, probably the spermatophores had been in the water for many hours. The effect of the cloacal secretion of the living female was then tried, to see if it would revive these spermatozoa; no such result was produced. Freshly obtained seminal fluid mounted in water retained its vitality for many hours; but as this experiment was not performed until April 18, only a small amount of seminal fluid could be obtained, and in this the sperms were not in a vigorous condition. If fresh seminal fluid were taken in the proper season and mounted in quantities to correspond with that deposited in a spermatophore, it might retain its vitality much longer. The viscous liquid in which the spermatozoa occur does not readily mix with water.

A freshly deposited spermatophore of *Triton viridescens* was obtained and kept in water; from time to time small portions of the ball of spermatozoa were teased apart and examined under the microscope. Eleven hours from the time the spermatophore was deposited, many active spermatozoa were found; an hour later all were motionless. Probably in an undisturbed spermatophore their vitality would be retained longer than twelve hours.

C. **The Eggs.** Those of *A. punctatum* have been described and figured by Clark ('80). The eggs, with their individual gelatinous envelopes, occur in compact bunches, surrounded by a very thick jelly mass. The entire structure is usually of an oval shape, often nearly as large as one's fist. The eggs of *A. tigrinum* are more loosely aggregated in a thinner jelly mass, and the cluster resembles a bunch of grapes. The clusters of eggs of *A. punctatum* are as a rule larger than those of *A. tigrinum*, and the number of eggs in a bunch is usually greater.

At the time of the discovery of the spermatophores, very few bunches of eggs could be found. The number steadily increased for a week; at the end of that time eggs were found in early seg-

mentation stages, showing that they had been quite recently laid. The egg-laying season follows immediately after the deposition of spermatophores, and lasts six or seven days. Nearly every bunch of eggs found on April 10 was close to a group of spermatophores.

On April 16, in the pond where 25 groups of spermatophores had been counted nearly a week before, about 55 bunches of eggs were found. Of these, many bunches were deposited in groups of two to four, probably by the same female. The number of aggregations of eggs very nearly equalled the number of groups of spermatophores.

D. **The Adults.** *Secondary Sexual Characteristics.* During the breeding season, at least, the cloacal region of the male is quite prominent; that of the single female examined was much less swollen, and the orifice was smaller. The cloaca of the male is lined with fine parallel papillated ridges, extending inward for a few millimeters; between these ridges are deep grooves, lined with cilia whose beat is outward. These ridges and grooves were not found in the single female examined. According to Kingsbury ('95) the female Amblystoma, as well as the male, has cilia in the cloaca but the tract is less extensive. The urogenital sinus of the male is larger than that of the female, probably to hold a considerable supply of seminal fluid preliminary to the deposition of a spermatophore. No secondary sexual characters to indicate the clasping of the female by the male were found.

II. DISCUSSION.

Andrews ('97) described the structure and distribution of some spermatophores which he attributed to *Amblystoma punctatum*, but without positive identification. He states that these spermatophores were more slender and higher than those of *Triton viridescens*, and were distributed, at intervals of a few inches, in lines of several to a dozen. I find it difficult to reconcile his account with my own observations.[1]

[1] Professor Andrews, to whom the manuscript of this paper was submitted, writes,— "The spermatophores vary in size, arrangement and form here (about Baltimore) in different years and ponds; and I think your comparison with a tree stump a good one to indicate their common form. I judge the discrepancy in our account to be one of words rather than of observations. I am convinced from your photograph and account that you have described the same spermatophores that I did, and I judge both observations — despite some differences in descriptions — refer to Amblystoma punctatum."

On account of the late season at which my investigation was begun, no direct observations of the process of fertilization were possible. Clark ('79) says of some specimens of *A. punctatum* in confinement: "The males showed no inclination to clasp the females, but quietly deposited quite large masses of an apparently rather thick liquid, opaque white, on the bottom of the dish in which they were kept. Upon examination this was found to consist of spermatozoa moving actively in a liquid." The manner in which the spermatozoa reached the eggs was not observed.

Fertilization is undoubtedly internal. Of this the evidence adduced by Kingsbury ('95), and the presence of spermatozoa in the cloaca of the female as described above, furnish sufficient proof. It remains to consider how the transfer of spermatozoa is effected by the spermatophores.

The number of spermatophores is evidently very much greater than the number of females; and unless there exists an enormous disproportion between the sexes, each male must deposit a large number of spermatophores. Their abundance and the manner of their distribution, render it a very easy matter for the female to find enough of them for purposes of fertilization. In some portions of the pond it would seem scarcely possible for a female to move about in the water for any length of time without brushing against some of these spermatophores; hence there is the possibility of finding them by chance contact.

In the cases of those Urodela in which, as in *Triton viridescens* (Jordan '91 and '93; Hilton '02) and Axolotl (Gasco '81) the number of spermatophores deposited by a single male is small, particular safeguards are needed in order to facilitate their delivery to the cloaca of the female. In these forms the physiological necessity which requires the co-operation of the female in order that spermatophores may be deposited insures the presence of the female at the right time; subsequent reactions safeguard the reception of at least one of these spermatophores by the female cloaca. In *Triton viridescens*, according to my own observations, in some cases the female seems to make a definite attempt to get the spermatophore. The complicated behavior of the adults in these cases finds its biological significance not only in the increasing certainty of the process, but in a corresponding economy in the

number of spermatophores that must be deposited. With *Amblystoma punctatum*, on account of the very large number of spermatophores, there is the probability of a simpler mode of behavior, and the spermatophores may be found largely by chance. The wastefulness of the method is obvious. In Amblystoma as in Axolotl there is evidently no clasping of the female by the male, such as occurs in Triton.

The result of the experimental work on the vitality of the seminal fluid in water indicates that the spermatophore is not necessarily taken up by the female immediately after it is deposited; probably it is capable of effecting fertilization after exposure to the water for many hours.

On account of the shortness of the breeding season, the spermatozoa can be retained in the cloaca of the female for only a few days at most, before fertilization is effected. The position with respect to the spermatophores, of the earlier eggs found, suggests that in some cases the eggs are deposited immediately after the spermatophores are picked up.

The extreme flexibility of the sperm is doubtless correlated with the process of internal fertilization. In Cryptobranchus, in which fertilization is external (Smith '07), the egg envelopes must be penetrated after a brief exposure to the hardening effect of the water, and a much more rigid spermatozoon is required.

In the evolution of terrestrial from aquatic vertebrate life, a transition from external to internal fertilization takes place. External fertilization is not adapted to terrestrial conditions, hence in the land-living vertebrates it occurs only in some of the forms that revert to the water during the breeding season — *i. e.* in the Amphibia. Internal fertilization is an adaptation to terrestrial life in the sense that it is a condition antecedent to that life, not a result brought about by it; it may occur in purely aquatic vertebrates, as in the Elasmobranchs and a few Teleosts. Internal fertilization by means of spermatophores is a method still adapted to aquatic rather than to terrestrial conditions. It is a method intermediate between external fertilization on the one hand and internal fertilization without spermatophores on the other. Viewed in the light of the habits of the higher vertebrates, the occurrence of any method of internal fertilization in a form that breeds in the

water represents an advance upon the habit of external fertilization, and a stage in the evolution of habits that are to make possible the invasion and permanent occupation of the land.

Internal fertilization also finds a biological significance in the fact that in the course of its development there is gradually effected an economy in the amount of seminal fluid required for fertilization. This factor may account for the persistent development of the habit under aquatic conditions, where external fertilization is still possible; the incidental result is a preparation for terrestrial life.

In existing Amphibia we may find illustrations of various stages in this evolution of the breeding habits correlated with a transition from the water to the land. In Cryptobranchus, one of the lowest of the Urodela, leading an aquatic life and showing only in its methods of respiration and locomotion an advance toward terrestrial conditions, external fertilization takes place. This is evidently the primitive condition for the Urodela. In Amblystoma, a urodele living partly upon the land but returning to the water to breed, we see developed the peculiar habit of fertilization by means of spermatophores — a mode of internal fertilization favored by aquatic conditions. In *Triton viridescens* an economy of seminal fluid through a reduction in the number of spermatophores is made possible by definite reactions on the part of the adults, which insure fertilization. In the urodeles *Megapterna montana* Savi., *Molge aspera* Dugès and *Glossoliga Hagenmulleri* Lataste, according to Bedriaga ('82 and '95) the male emits spermatophores while still clasping the female; in *Triton torosus* Esch. (Ritter '99) it is probable that a very similar process occurs; in none of these cases, with the possible exception of *Molge aspera*, is there direct cloacal contact. Finally in the Apoda (the Sarasins '87–'93; Brauer '97) we find the establishment of a method of internal fertilization by direct cloacal contact, thus fulfilling the requirements for continuous residence upon the land.

University of Michigan Zoological Laboratory
Ann Arbor, Michigan

LITERATURE CITED.

ANDREWS, E. A.

1897. Breeding Habits of the Spotted Salamander (Amblystoma punctatum). Amer. Nat., Vol. 31, pp. 635–7.

DE BEDRIAGA, J.

1882. Ueber die Begattung bei einigen geschwänzten Amphibien. Zool. Anz., Bd. V, pp. 265–268, 357–359.

1895. On the Pyrenean Newt, Molge aspera Dugès. Proc. Zool. Soc. 1895, p. 150.

BRAUER, AUGUST.

1897. Beiträge zur Kenntniss der Entwicklungsgeschichte und der Anatomie der Gymnophionen. Zool. Jahrb. Anat., X, p. 389.

CLARKE, S. F.

1880. Development of Amblystoma punctatum. Studies from Biol. Lab. of Johns Hopkins Univ., No. II.

GASCO, P.

1881. Les Amours des Axolotls. Zool. Anz., IV, pp. 313, 328.

HILTON, WILLIAM A.

1902. A Structural Feature Connected with the Mating of Diemyctylus viridescens. Amer. Nat., Vol. 36, pp. 643–51.

JORDAN, EDWIN O.

1891. The Spermatophores of Diemyctylus. Journ. Morphol., Vol. X, No. 2.

1893. The Habits and Development of the Newt (Diemyctylus viridescens) Journ. Morphol., Vol. VIII, No. 2.

KINGSBURY, B. F.

1895. The Spermathecæ and Methods of Fertilization in Some American Newts and Salamanders. Trans. Am. Micr. Soc., Vol. 17, pp. 261–304.

RITTER, W. E.

1897. Diemyctylus torosus Esch. The Life History and Habits of the Pacific Coast Newt. Proc. Cal. Acad. Sc., Third Series, Zoology, Vol. I, No. 2, 1897.

SARASIN, P. B. AND C. F.

1887–1893. Zur Entwicklungsgeschichte und Anatomie der Ceylonischen Blindwühlen, Ichthyophis glutinosus. Ergebnisse naturwissenschaftlicher Forschungen auf Ceylon, II.

SMITH, BERTRAM G.

1906. Preliminary Report on the Embryology of Cryptobranchus allegheniensis. Biol. Bull., Aug. 1906.

1907. The Life History and Habits of Cryptobranchus allegheniensis. Biol. Bull. (In press.)

ZELLER, E. v.

1905. Untersuchungen über die Samenträger und die Kloakenwulst der Tritonen. Zeitschr. wiss. Zool., Bd. 79.

THE STAFF-TREE, *CELASTRUS SCANDENS*, AS A FORMER FOOD SUPPLY OF STARVING INDIANS

FRANK T. DILLINGHAM

In many kinds of hard and horny seeds there is present, as a reserve material, a carbohydrate which upon hydrolysis yields *mannose* (a simple sugar closely related to glucose). This carbohydrate has been named *mannan*. It is one of the hemi-celluloses, a group of substances closely resembling in appearance the true celluloses, but easily resolved into simpler carbohydrates by the hydrolytic action of enzymes or of dilute acids. There is no lack of evidence that mannan which occurs abundantly in the so-called vegetable ivory, *Phytelephas macrocarpa*, and in the seeds of many other palms, as well as in the wood of coniferous trees, is in spite of its hardness, fit food for camels, neat cattle, sheep, and various rodents. This is illustrated in the girdling of pine trees by mice, as recorded by Thoreau in "Walden."[1] He says:—"There were scores of pitch-pines around my house, from one to four inches in diameter, which had been gnawed by mice the previous winter,— a Norwegian winter for them, for the snow lay long and deep, and they were obliged to mix a large proportion of pine bark with their other diet. These trees were alive and apparently flourishing at mid-summer, and many of them had grown a foot, though completely girdled; but after another winter such were without exception dead. It is remarkable that a single mouse should thus be allowed a whole pine tree for its dinner, gnawing round instead of up and down it; but perhaps it is necessary in order to thin these trees, which are wont to grow up densely."

It is known that the root of a Japanese plant, *Conophallus konnjaku*, rich in mannan is used as human food, and the question may fairly be asked whether the former use of bark bread by the inhabitants of Scandinavia might not have been dependent upon the mannan in the bark. After discussing this matter in the

[1] Walden, p. 300. Jas. R. Osgood & Co. Boston, 1876.

Bulletin of the Bussey Institution (1906, Vol. 3, pp. 120–128), the writer learned that some tribes of North American Indians in times of extreme dearth were accustomed to keep body and soul together by boiling and eating the bark of the Staff-tree, *Celastrus scandens*. The Staff-tree is also called the staff-vine; false, climbing or shrubby bittersweet; wax-work, fever-twig, yellow-root, climbing orange-root and Jacob's ladder.

Radisson, wintering near the outlet of Lake Superior about the year 1658, found the Indians suffering greatly from starvation He writes:[1]— "Those that have any life seeketh out for roots, which could not be done without great difficulty, the earth being frozen 2 or 3 feet deep, and the snow 5 or 6 above it. The greatest subsistence that we can have is of rind tree which grows like ivy about the trees; but to swallow it, we cut the stick some 2 foot long, tying it in fagot, and boil it, and when it boils one hour or two the rind or skin comes off with ease, we take and dry it in the smoke and then reduce it into powder betwixt two grain stones, and putting the kettle with the same water upon the fire, we make it a kind of broth which nourishes us, but become thirstier and drier than the wood we ate."

In the Report of the U. S. Commissioner of Agriculture for 1870, (p. 422), there is the following statement:— "The Chippewa Indians use as food the tender branches of the Staff tree (*Celastrus scandens*). This climbing shrub, the *bois retors* of the French, or twisted wood, is sometimes called *bitter sweet*. It has a thick bark and is sweetish and palatable when boiled."

In view of the above statements, specimens of both the bark and the wood of the Staff-tree were tested for mannan. On the grounds of the Bussey Institution, on Jan. 24th, 1907, branches of the Staff-tree were cut in pieces about one foot in length. Both the inner and outer bark were removed together, no attempt being made to separate them. The outer bark was thin, but the inner bark was thick and fleshy. The material was carefully dried, ground to a fine meal, and a weighed quantity of it was boiled with dilute hydrochloric acid for three hours. A small portion of the liquor thus obtained was neutralized with sodium hydroxide and examined for mannose by the addition of a few

[1] Voyages of P. E. Radisson, p. 204, Prince Society Edition, Boston, 1885.

drops of phenylhydrazine acetate. No mannose hydrazone crystals formed at this point. The remainder of the liquor, after being similarly neutralized, was evaporated to dryness; the residue was treated with a small quantity of water; and the concentrated liquor thus obtained was tested for mannose by adding a few drops of phenylhydrazine acetate. With the aid of the microscope, the formation of characteristic crystals of mannose hydrazone was observed.[1] The wood proper (including the pith) was reduced to a fine meal and then treated in precisely the same manner as was the bark.

From these tests it appears that unlike the bark of most deciduous trees, that of the Staff-tree contains an abundance of mannan. The bark of the Staff-tree, moreover, contains a larger quantity of mannan than does the wood proper.

To confirm Radisson's statement as to the effect of boiling, a few branches of the Staff-tree were boiled with water for about one hour. At the end of this time the bark was found to peel off with great ease. It was seen to be thick, pulpy, and very mucilaginous, and it had a rather agreeable taste.

It is evident from these experiments that a part, at least, of the physiological value of the bark of the Staff-tree may be justly attributed to the presence of mannan.

Bussey Institution of Harvard University
Jamaica Plain, Mass.

[1] This method has been explained in detail in the Bulletin of the Bussey Institution. 1902, 3, p. 30. 1903, 3, p. 47.

NOTES AND LITERATURE

GENERAL BIOLOGY

The Spirit of Nature Study.[1]— Nature may be approached in a very unscientific spirit. Thus Emerson was led to dedicate to the *Botanist* the following quatrain:

> Go thou to thy learned task,
> I stay with the flowers of Spring:
> Do thou of the Ages ask
> What me the Hours will bring.

What the hours brought he so expressed that the Rhodora has become a universal type of botanic beauty. In a different spirit the New England botanists named their journal *Rhodora*, for they profess to have been uninfluenced by Emerson's familiar lines; they sought a characteristic local plant with a short name which would commend itself to bibliographers. The spirit of nature study, according to Dr. Bigelow's interpretation, combines the sentimental and the scientific, with its emphasis upon the former. This appears in such advice as,— "Take frequent rambles into the country; associate with natural objects, love them, take them into your nature, and treasure the remembrances of them .... Subsequent years of trouble cannot obliterate the charmed impressions." "At the next stopping place there will be no fairer landscapes, nor more beautiful skies, no statelier trees, more joyous songsters, nor brighter flowers; more cheerful hum of insects, more invigorating air, no more happiness, no better friends, and no better God."

Therefore more time should be given to nature study in the schools, and many educators are quoted to this effect. School children should be taken to the country and should have plants and animals at home; rabbits and gourds are particularly recommended since the former are reasonably small and the latter grow upward 'where land is cheap.' College methods of instruction should not be extended to elementary schools. Of the sixteen half-tones which illustrate the book, twelve are photographs of boys and girls out in the country.

The nature student, as Burroughs has said, does not regard birds

[1] Bigelow, Edward F., *The spirit of nature study*. New York, A. S. Barnes & Company, 1907. 12mo, 222 pp.

as ornithological specimens, nor wild flowers as material for herbaria. Dr. Bigelow's expeditions are not for 'what one can get.' It is apparent that within the present century the destruction of such irreplacable plants and animals as remain will not be tolerated, either for sport, for food, or for amateur collections. Since nature study in the schools should save the swallows' banks from the small boy and protect native plants from bouquet gatherers, it may prove of great value to the community. This, however, is not strongly presented in Dr. Bigelow's book, which includes a photograph of eleven women gathering bunches of violets, and recounts, as one of the author's pleasurable reminiscences, the bloody death of a woodchuck.

Dr. Bigelow's twenty-three informal essays are enlivened by many quotations and anecdotes; their author appreciates the "fun of being a naturalist" and his good natured humor is all at the expense of the "bug-hunter's" critics. He is at home with boys and girls for whom he edits each month an excellent department of Nature and Science in *St. Nicholas*, but the book here considered is addressed to parents and to teachers of nature study.

Heterogenesis.— The idea that eggs of one species may give rise to adults of other species still finds an occasional advocate undismayed by overwhelming evidence to the contrary. A contribution recently submitted to the *Naturalist* set forth breeding experiments in which several species of insects hatched from a single batch of eggs, and none were parasites. The suggestion of a distinguished entomologist that in these days of the multiplicity of species, several might readily arise from one lot of eggs, was here inapplicable, for different genera were involved. The probable explanation is that the technique of the experiments was faulty. Dr. H. Carlton Bastian continues to believe in heterogenesis, upon which he has published voluminously, but a skeptical critic of his latest book concludes with the following anecdote.[1] "On one occasion, Dr. John Rennie, lecturer on parasitology in the University of Aberdeen and an expert investigator, observed two infusorians moving inside a rotifer's egg, but he did not regard the phenomenon as a proof of heterogenesis. As a matter of fact the egg envelope showed a small split through which the infusorians soon passed out, doubtless following the path by which they formerly entered."

F. T. L.

[1] Bastian, H. C. *The evolution of life*. Reviewed in *Nature*, May 2, 1907, vol. 76, p. 1.

ZOOLOGY

Anatomical Terminology.[1] — In descriptive anatomy, as in systematic zoology, synonymy has been a heavy burden. In a current text book a paragraph of five lines begins with "*The Corium, Cutis vera, Dermis*, or *True Skin*"; and another, which is not exceptional, announces "*The Simple Follicles, Intestinal Glands, Crypts*, or *Glands of Lieberkühn, glandulæ intestinales* [*Lieberkuehni*]." In America since 1871, Professor Burt G. Wilder has been active in reform with the following results. In 1889 the Association of American Anatomists voted to employ the adjectives *anterior, posterior, dorsal* and *ventral*, in the sense of toward the head, tail, back, and abdomen respectively. They substituted *thoracic vertebra* for dorsal vertebra, and approved the terms *calcar, hippocampus, pons, insula, pia*, and *dura*. In 1896 the Neurological Association adopted forty terms pertaining to the nervous system. The Association for the Advancement of Science went so far as to sanction the most unfortunate principle of Professor Wilder's system, namely that terms should be single words rather than descriptive phrases. This principle leads (1) to the introduction of shorter new names to replace more familiar older ones; (2) to the omission of nouns, making the descriptive adjective the complete term; and (3) to the fusion of two words in one, often combined with the elimination of certain syllables. The omission of *mater* from dura mater, and of *tunica* from tunica muscularis is common and desirable in the laboratory, but the noun is understood and is an essential portion of the name. Nothing is gained by ruling it out of existence. The following are examples of fused words, — *transection* for transverse section; *postcava* for vena cava posterior; *alinjected* for injected with alcohol; *terma* for lamina terminalis. In this system the elimination of synonyms becomes secondary to a kind of anatomical spelling reform.

In 1889 the Anatomische Gesellschaft appointed a committee of nine eminent anatomists to revise anatomical nomenclature, and after six years' labor it reported a list of about forty-five hundred Latin terms. An even larger number of synonyms was rejected. Unfortunately *anterior* is used as equivalent to *ventral*, *superior* is some-

[1] Barker, Lewellys F., *Anatomical terminology*. Philadelphia, P. Blakiston's Son & Co., 1907. 8vo, ix + 103 pp., 5 figs.

times employed for *anterior*, and in some other instances, as in naming the dorsal pancreas *accessory pancreas*, the bias of human anatomy is apparent. In this respect Professor Wilder's rejected principle ought not to be abandoned. The German committee has adopted thirty-four of the forty terms sanctioned by the American Neurological Association; in ten of these, however, nouns which had been dropped as superfluous are retained. In general, the committee declined to introduce new terms, to combine nouns and adjectives, or to eliminate syllables or letters for brevity. It followed Professor Wilder's advice in preferring descriptive to personal names, definitely retaining only two of the latter, *Wolffian* and *Muellerian*. Intestinal glands, parotid duct, splenic nodule, and renal corpuscle replace glands of Lieberkuehn, Stenson's duct, and Malpighian corpuscle, the last term having been applied to radically different parts of the spleen and kidney.

After a trial of more than ten years this anatomical nomenclature adopted at Basle, and known consequently as the BNA, has become the standard terminology. The writer has found it necessary to have the report of the German committee always at hand. This report has been made easily available by Professor Barker of Johns Hopkins University. In a preface of twelve pages he describes the origin of the Basle nomenclature. On the left hand pages of his book are the Latin terms in two columns, reprinted in full and without modification from the German report. On the right hand pages there are two corresponding columns of English translations of the terms, together with some of the current rejected names. He says, on page 1, "The English vocabulary is simply explanatory; in many instances it would be unwise to use the English synonyms given, and in many more instances anatomists would differ as to the most suitable English equivalent to be chosen. Each anatomist is of course at liberty to use whatever English equivalent he desires for the official Latin terms. Students are strongly advised, however, to use the original Latin terms as English words. The Latin terms are the only authorized ones." We agree with Professor Barker that "the sooner a general decision to adopt these terms is reached, the better it will be of anatomical instruction and research, and the easier it will be for teacher and taught."

F. T. L.

The Blending and Overlap of Instincts in Birds.[1] — Wild birds are described as passing annually through a cycle of instinctive activities

[1] Herrick, F. H. Analysis of the cyclical instincts of birds.— The blending and overlap of inst'ncts. *Journ. of Comp. Neur.*, 1907, vol. 17, pp. 194–197.

including (1) spring migration; (2) courtship and mating; (3) nest building; (4) egg laying and incubation; (5) care of young; and (6) fall migration. Some birds, like the robin and blue bird, pass through two or three reproductive cycles before the fall migration. The fish hawks and eagles which repair their old nests in the autumn do not act in "anticipation of spring" but exhibit a recurrence of the nesting instinct, due to beginning a new cycle which is never finished. Young birds may be abandoned in the fall when the migratory impulse overlaps the parental instinct. "An adult robin has been seen to offer a string to its fully grown young, and try to cram it down the throat of a fledgling. Later the old bird flew with the string into a tree. This was the result of the overlapping of two reproductive cycles. The bird was alternately swayed by opposing impulses, now being impelled to gather nesting material when she picked up the string, now by parental instinct to feed her young when she tried to serve it, and again possibly by the instinct of building when she flew with the string into a tree."

When a vireo's nest contains a cowbird's egg and a new story is added to the nest by the vireo, it is not for the purpose of eliminating the cowbird's egg, which it does so perfectly. It indicates rather that the reproductive cycle has been broken by fear, and a new one is begun, in these rare cases the old nest being retained as a site to build upon. The herring gull also will bury its eggs when its cycle has been interrupted through fear.

This interesting interpretation of anomalous actions in birds is followed in the Journal of Comparative Neurology by an extraordinary explanation of the brooding habit of the male salamander, *Cryptobranchus allegheniensis*.[1] It states that "after the eggs are deposited they are usually guarded for a time by the male, who fights and drives away other hellbenders which attempt to eat the eggs. The male himself eats some of the eggs, but on account of the slowness of his digestion is unable to eat more than a small proportion, hence his presence is in the main protective. In defending the eggs the male is only guarding his own food supply: the origin of the brooding habit in this case seems to be the feeding habit." If one doubts that the perpetuation of this species depends upon a providential slowness of digestion, a blending of the feeding and brooding instincts may be substituted.

F. T. L.

[1] Smith, B. G. The habits and life history of *Cryptobranchus allegheniensis*. *Journ. of Comp. Neur.*, 1907, vol. 27, pp. 197–198.

A Preliminary Note on the Variation of Scutellation in the Garter Snakes.— Three years ago the writer began an investigation into the relationships of the different races of garter snakes (Thannophis) in an attempt to determine the laws involved in the differentiation of the genus. The results of this work are being included in a monograph of the genus, but as it will be several months before this work can be completed it has been thought best to publish a brief outline of some of the conclusions.

In the progress of this investigation it was seen very early that before a serious attempt could be made to determine the affinities of the different races, the significance of the variations in scale arrangement or scutellation must be determined. This was attempted with the following results:

(1) The number of dorsal scale rows on an individual snake decreases posteriorly by the elimination of certain rows, and the series eliminated are always the same for snakes with the same number of rows, as for example *T. sirtalis* and *T. saurita*.

(2) The rows dropped posteriorly in individual snakes are those which have entirely disappeared in races with a fewer number of scale rows.

(3) The reduction in the number of dorsal scale rows is generally accompanied by a reduction in the number of labial, ventral, and subcaudal scales (gastrosteges and urosteges).

(4) There is considerable evidence that the reduction in scutellation is directly or indirectly associated with a diminution in size.

The general reduction in scutellation described above is exhibited by each of the several (natural?) groups into which the genus can be divided. These groups all occur together only in northern Mexico, which may be considered the center of origin for the genus. The races that occur in this region all exhibit the maximum scutellation for their respective groups, the dwarfing in size and scutellation taking place at points away from the center of origin. The discovery of these methods of variation in the different series of scales has been an indispensable aid in determining the affinities of the different races.

ALEXANDER G. RUTHVEN

A Simple Method for removing the Gelatinous Coats of Eggs.— In the course of work in which it was necessary to handle a number of amphibian eggs the writer hit upon a simple and rapid method of freeing them from their gelatinous envelopes. While, because of its

very simplicity, it seems impossible that other workers have not used the method, still the writer has been able to find no reference to it in embryological literature and he records it here, therefore, because he feels that it will be very serviceable to workers who have to handle such material.

The method consists simply in placing the egg on a bit of blotting paper and then rolling it over and over, thus reversing the small boy's method of rolling up a large snow ball. Either fresh or preserved eggs may in this way be rapidly removed from their envelopes and transferred by means of a spear-headed needle or a paper spatula to the fixing reagent. The method worked well on frog and salamander eggs that had been preserved in formalin for two years, and on millipede eggs which had been similarly preserved for over three years.

When using the method with certain kinds of fresh material, the eggs may be so soft that when finally unrolled from their coats they are drawn down so as to adhere tightly to the blotting paper. To avoid this, (1) roll them off onto a paper of harder texture just before the last trace of gelatinous film has been removed from their surfaces, or (2) first fix them (*e. g.*, in Gilson's mercuro-nitric mixture) and then, before further hardening in alcohol, roll them out of their envelopes on the blotter.

MICHAEL F. GUYER

The Star-nosed Mole on Long Island, N. Y.— In a recent (1902) list of the mammals of Long Island, Arthur H. Helme states that the only evidence of the presence of the star-nosed mole (*Condylura cristata*) on the island that has come to his knowledge is the finding of a single dead specimen. It seems then worth recording that on April 18 a star-nosed mole, which had been caught by a cat, was sent me from Great Neck, Long Island, by Miss Elise Gignoux.

JOHN TREADWELL NICHOLS

Notes.— Under the name *Cirrodrilus cirratus* U. Pierantoni has described[1] a peculiar-looking worm, about 3 mm. long, found as a parasite on the crayfish of Japan. It is cylindrical, and consists of a large head and following this eight body segments, the anterior six having short fleshy finger-like processes arranged in a transverse line on the ventral surface. The mouth is nearly surrounded by a ring of similar longer processes, whence the name cirratus. The mouth is armed with a pair of horny jaws like those of certain Branchiob-

[1] Bolletino Societià di Naturalisti in Napoli, 19, 1905.

dellids with which group (or the Histriodrilids) the author is inclined to place it. The internal structure was not studied.

The Systematic Position of Trichoplax. Ever since its discovery Trichoplax has been one of the zoological problems, and now Thilo Krumbach of Breslau offers evidence[1] to show that it may be the planula of the hydroid Eleutheria. His proof is not conclusive but is based upon the histological similarities between the planula and Trichoplax, and upon the fact that Trichoplax appeared suddenly in great numbers in a tank where the nudusa *Eleutheria krohni* occurred. He suggests also that Monticellis *Treptoplax reptans* belongs to *Eleutheria claparedi.*

Caesar Böttger reports[2] *Petricola pholadiformis* from the North Frisian Islands, and quotes also its presence from the East Frisian Islands. It has previously only been known from the Atlantic coast of America. It is now distributed over quite a territory and the problem is how and when did it reach the old world?

Kofoid points out[3] that the genus Polykrikos which occurs abundantly at San Diego, California, is really a colonial infusorian consisting of two, four or rarely eight zooids and that its place is in the family Gymnodinidæ of the Dinoflagellates. Apparently the same species, *Polykrikos schwartzi* occurs on the Californian and European coasts. *P. auricularia* of Bergh is regarded as a synonym.

Haswell[4] repeats his observation of Euglena-like organisms as intracellular parasites in rhabdocoele turbellarian worms.

The Museum at Bergen, Norway, has begun the publication of a series of monographs dealing with the marine fauna of the vicinity. The second and third *Hefte* issued last year, but only now received, deal with the Bryozoa by O. Nordgaard and the Decapod Crustacea by A. Appellöf.

J. S. KINGSLEY.

[1] Zool. Anzeiger, 31, p. 450, 1907.
[2] Zool. Anzeiger, 31, p. 268, 1907.
[3] Zool. Anzeiger, 31, p. 291, 1907.
[4] Zool. Anzeiger, 31, p. 296, 1907.

BOTANY

Cytology and Mutation.— Immediately after the rediscovery of Mendel's law and the publication of DeVries's great work on mutation, cytologists began seeking for some basis for these phenomena in the organization of the germ cells. The most recent contribution to the literature of this subject is a paper by Gates[1] on *Œnothera Lamarckiana* and *O. lata.*

The author finds that the regular abortion of the pollen in *Œnothera lata* is not due to the filling of the anther cavity or loculus by an ingrowth of its lining (the tapetum) as described by Pohl, but to some other agency the nature of which is not yet explained. Pollen development may proceed to the formation of the tetrads, but degeneration of both the mother cells and the tapetum frequently begins in the resting stage or in the prophase of the first mitosis. If the tapetal cells always degenerated before the pollen mother cells, we might conclude that the failure of the former to secrete nutriment for the pollen was the immediate cause of sterility. But this is not always the case for the degeneration of the pollen mother cells may precede that of the tapetum. The writer is inclined to accept the hypothesis that the maternal and the paternal chromatin remain separate in the somatic cells, and also in the germ cells until maturation approaches. Then the intimate union which occurs during synapsis may lead to incompatibilities between the plasms and to the more or less complete failure of further development.

A second point of interest is the demonstration of peculiar chromosomes, called "heterochromosomes." They arise in *O. lata* in the prophase after synapsis by the cutting off of a portion or loop of the spireme thread before the remainder breaks up into chromosomes. A cell may contain one or two of these bodies which appear as large rings, usually seen in the cytoplasm near the spindle. They do not divide but become smaller and probably disappear at the end of the first mitosis. In the *O. Lamarckiana* hybrid these bodies also occur. The author thinks that they represent discarded chromosomes and are, perhaps, a means of lessening the number of chromosomes in certain

[1] Gates, R. R. Pollen development in hybrids of *Œnothera lata* × *O. Lamarckiana*, and its relation to mutation. *Bot. Gaz.*, 1907, vol. 43, pp. 81–115, pl. 2–4.

germ cells. Some mother cells do not contain them, but it could not be demonstrated that these have fewer ordinary chromosomes than the others. The number of chromosomes in *O. lata* is fourteen; in the hybrid with *O. Lamarckiana* it is "probably twenty"; and in pure *O. Lamarckiana* the number, as yet undetermined, is thought to vary. Since a different number of chromosomes in closely related species has apparently never before been recorded, these observations if they are verified by further investigations are of great interest. The author dismisses the idea that *O. Lamarckiana* is itself a hybrid, but this also is an important subject for further study. He concludes that the mutations of *O. Lamarckiana* probably arise during the reduction divisions, and that the pollen grains which give rise to mutants may differ in their chromatin morphology from the ordinary pollen of the plant.

J. A. HARRIS

Variation and Differentiation.— Dr. Pearl has recently published an exhaustive study of the intra-individual variation and differentiation in Ceratophyllum.[1] The purpose of the author was "to work out as exactly and completely as possible for a particular organism the laws according to which post-embryonic differentiation and growth occur." The characters considered are (a) the number of leaves per whorl; (b) the position of the whorl on the plant; (c) the size of the various divisions of the plant; and (d) the position of the branches. It is found that the mean number of leaves per whorl is greatest on the main stem and decreases on the primary, secondary, tertiary and quaternary branches. The variability — measured by both the standard deviation and the cœfficient of variation, on the other hand, increases on the branches of the first and second order to fall again on those of the third and fourth order. The skewness also seems to increase in the negative direction from the main stem outward but the shortness of the material does not permit of the determination of this point by analytical methods beyond the secondary branches. A marked correlation is found between the position of the whorl on the stem and the number of leaves. The number of leaves increases from the base to the tip of the axis but the increase cannot be represented by the slope of a straight line — in biometric terminology, regression is not linear — or by a parabola. The increase is, however,

[1] Pearl, R. Variation and Differentiation in Ceratophyllum. *Carnegie Institution of Washington*, 1907, Publ. 58, 136 pp., 26 figs., 2 pl.

well represented by a logarithmic curve. This is the first law of growth in Ceratophyllum and may be stated as follows: "On any axial division of the plant the mean number of leaves per whorl increases with each successive whorl in such a way that both the absolute increment and the rate of increase diminish as the distance (in units of nodes) of the whorl from a fixed point increases."

The second law of growth is that of diminishing variability. The whorls of leaves produced by a growing point are formed with ever increasing fidelity to type. "The growing point appears to be influenced in its morphogenetic activity by its previous experience."

To the students of evolution, who are now concerning themselves primarily with experimental and statistical investigations of variation and heredity, the importance of such a detailed study of intra-individual variation, correlation and differentiation will be apparent. In the original paper they will find a wealth of analyzed material.

J. A. HARRIS

Cotton.— *Its Cultivation, Marketing, Manufacture, and the Problems of the Cotton World.* By Charles William Burkett, Professor of Agriculture, North Carolina College of Agriculture and Mechanic Arts, and Clarence Hamilton Poe.[1]— This volume of over three hundred pages is interesting from many points of view. Its illustrations are reproductions in a sepia tone of much effectiveness and the contrasts, especially in the case of white cotton bolls are very pleasing. Moreover many of the sketches are likely to be of permanent interest as matters of record, notably those which give some notion of fast-vanishing methods of carding, spinning, and weaving cotton by hand. The authors have spared no pains to make the illustrations attractive and useful, and they have succeeded admirably. The text is clearly written, throughout, and it is well-arranged with respect to convenience of reference. Moreover, the facts as regards the botany, the agriculture, and the commercial relations of the cotton-plant, are carefully stated in such a manner as to be quite within the reach of the general reader, but we miss what ought never to be lacking in any book of reference,— an index. The value of this useful treatise would be enhanced tenfold by a copious alphabetical and subject index.

G. L. GOODALE

Notes. — Three new species of Dendromecon are described by Fedde in *Repertorium Novarum Specierum* of Jan. 15.

[1] New York, Doubleday, Page & Company.

Notes and illustrations concerning *Robinia Neo-Mexicana* are published by Phillips in *Forestry and Irrigation* for February.

An illustrated economic account of *Nyssa aquatica*, by von Schrenk, has been reprinted from the "Silver anniversary edition" of *The Southern Lumberman.*

Vaccinium Dobbini is the name proposed by Burnham in *The American Botanist* of February for a New York relative of *V. vacillans.*

A revision of Spilanthes, by A. H. Moore, constituting no. 33 of the new series of "Contributions from the Gray Herbarium of Harvard University," is published as vol. 42, no. 20 of the *Proceedings of the American Academy of Arts and Sciences.*

A paper on Citharexylum, by Greenman, forms *Publication 117* of the Field Columbian Museum.

On Pringle's Santa Catalina Mountain material of 1881, Dode bases a new *Juglans elæopyren* in the *Bulletin de l'Herbier Boissier* of February 28.

An economic account of the walnut in Oregon is published by Lewis in *Bulletin no. 92* of the Agricultural Experiment Station of that State.

A new Californian oak, *Quercus Pricei*, is described by Sudworth in *Forestry and Irrigation* for March.

Several new aloids and other succulents are described by Berger in vol. 4, no. 38 of the *Notizblatt des K. Botanischen Gartens und Museums zu Berlin.*

Agave deserti is figured in detail in *Icones Selectæ Horti Thenensis*, vol. 6, fasc. 1.

A series of notes on Abietineæ, by Hickel, are appearing in the *Bulletin de la Société Dendrologique de France.*

Cardot and Thériot report on a collection of 63 Alaskan mosses in vol. 2, no. 13 of the *University of California Publications, Botany.*

Vol. 7, part 2, of *North American Flora* is occupied with a part of the Uredinales, by Arthur.

An extensive and well illustrated paper by Lyman on "Culture Studies on Polymorphism of Hymenomycetes," constituting no. 64 of the "Contributions from the Cryptogamic Laboratory of Harvard University," forms vol. 33, no. 4 of the *Proceedings of the Boston Society of Natural History.*

An enumeration of the fungi collected by Simmons on the second Norwegian Polar expedition, by Rostrup, was published in no. 9 of the *Report* on the Expedition shortly before the death of the author, which occurred in January.

Several quite distinct puff balls and phalloids of Argentina are described and figured by Spegazzini in a paper recently distributed from vol. 16 of the *Anales del Museo Nacional de Buenos Aires.*

A flora of Central Europe, with text cuts and colored plates, by Hegi and Dunzinger, is being issued in 70 monthly parts from the Lehmann Press of Munich.

With vol. 3, fasc. 7, issued in December, Coste's "Flore Descriptive et Illustrée de la France" etc. was brought to a conclusion, the final signatures dealing with Pteridophytes.

An ecological systematic account of the flora of Columbia, Missouri, by F. P. Daniels, forms vol. 1, no. 2 of the Scientific Series of *The University of Missouri Studies.* Twelve new species or varieties and 26 new names occur in the list, which includes 13 genera, with 19 species, of Pteridophytes and 422 genera, with 1039 species, of Spermatophytes.

A general biological study of the sand areas of Illinois, by Hart and Gleason, forms vol. 7, article 7 of the *Bulletin of the Illinois State Laboratory of Natural History.*

The distribution and adaptation of the vegetation of Texas are discussed by Bray in *Bulletin no. 82* (Scientific Series no. 10) of the University of Texas.

A study of the flora of the Sand Keys of Florida, by Millspaugh, forms *Publication 118* of the Field Columbian Museum.

A further paper on the grasses of Argentina has been published by Stuckert in vol. 13 of the *Anales del Museo Nacional de Buenos Aires.*

The first fascicle of vol. 3 of Arechavaleta's "Flora Uruguaya" has recently been issued as a part of vol. 6 of the *Anales del Museo Nacional de Montevideo.*

Mr. Cook's concept of "Kinetic Evolution" is set forth in extenso in a large brochure of vol. 8 of the *Proceedings of the Washington Academy of Sciences*, issued on February 13th.

Separates of Dr. Robinson's paper on "The Problems of Ecology" have been distributed from vol. 5 of "*Congress of Arts and Sciences, Universal Exposition, St. Louis, 1904.*"

Studies on the pollination of Wisconsin flowers are being published by Graenicher in current numbers of the *Bulletin of the Wisconsin Natural History Society.*

Von Ihering contributes an illustrated account of the myrmecophilous Cecropias to recent numbers of Engler's *Botanische Jahrbücher.*

Dissemination by the aid of ants is the subject of a well illustrated memoir by Sernander, forming vol. 41, no. 7 of the *K. Svenska Vetenskapsakademiens Handlingar.*

A large preliminary paper on the fungi of certain termite nests, by Petch, is published, with illustrations, in vol. 3, part 2 of the *Annals of the Royal Botanic Gardens, Peradeniya.*

A comprehensive bibliographic, botanical and physiological memoir on tannoids, by Dekker, forms no. 35 of the *Bulletin van het Koloniaal Museum te Haarlem,* printed in December last.

A long list of plants known to contain prussic acid is separately distributed by Greshoff from the 1906 *Report of the British Association for the Advancement of Science.*

Studies on the influence of spectral colors on the sporulation of Saccharomyces are reported by Purvis and Warwick in vol. 14, part 1 of the *Proceedings of the Cambridge Philosophical Society.*

The root-knees of Sonneratia are well figured in the *Annual Report of the Director of Forestry of the Philippine Islands for the Period July, 1905 to June 30, 1906.*

A rope-like tumor of *Betula populifolia* is described and figured by Penhallow in a separate from vol. 12 of the *Transactions of the Royal Society of Canada.*

An illustrated account of commercial seeds of brome grass and blue grass and their adulterants, by Roberts and Freeman, forms *Bulletin 141* of the Kansas Agricultural Experiment Station.

Tobacco breeding is considered by Shamel and Cobey in *Bulletin no. 96* of the Bureau of Plant Industry, U. S. Department of Agriculture.

An illustrated editorial account of the Mexican "guayule" is being published in current numbers of *The India Rubber World.*

A discussion of timber under conditions of modern demand and growth, by von Schrenk and others before the New England Railroad Club, has been distributed in pamphlet form by the Rand Avery Supply Company of Boston.

A series of "Forest Planting Leaflets," each dealing with a single species, is being published as *Circulars of the Forest Service* of the United States Department of Agriculture.

Studies of the wood of Javan trees, by Moll and Janssonius, are being published by the Brill Press of Leiden.

A second edition of the useful "Key to the Genera of Woody Plants in Winter," by Wiegand and Foxworthy, has been issued by the authors, whose address is Ithaca, N. Y.

A portrait, with short biographic sketch, of the late Sir Thomas Hanbury is given in The *Gardeners' Chronicle* of March 16th.

A portrait of H. N. Ridley is given in *Tropical Life* for January.

An appreciative notice of Marshall Ward, by the late Director of Kew Gardens, appears in *The New Phytologist* of January 31.

Fascicle 4 of de Wildeman's "Enumération des Plantes Récoltées par Emile Laurent," issued in February, contains a portrait and biographic sketch of Laurent.

Further articles on Burbank and his work, by DeVries, appear in the *Biologisches Centralblatt* for September, *The Open Court* for November, and *The Century Magazine* for March.

W. T.

GEOLOGY.

The Elements of Geology.[1]— Professor Norton of Cornell College, Iowa, has sought to present to the public an elementary textbook on geology "in which causes and their consequences should be knit together as closely as possible." He accordingly departs from the usual three-fold division into dynamical, structural, and historical geology, treating geological processes and the forms or structures which they produce in immediate connection, under the headings "External Geological Agencies" and "Internal Geological Agencies." A third part of the book treats of Historical Geology.

Under the heading "External Geological Agencies" the work of

[1] Norton, William Harmon, *The Elements of Geology*. Boston, Ginn & Company. x + 462 pp., 374 illustrations.

the weather and the work of ground water are first considered, after which the work of rivers, glaciers, winds, and the sea are considered in the order indicated. A final chapter in this part of the book discusses off-shore and deep-sea deposits. Under the heading "Internal Geological Agencies" the following chapters appear: Movements of the Earth's Crust, Earthquakes, Volcanoes, Underground Structures of Igneous Origin, Metamorphism and Mineral Veins. Historical Geology is treated in the usual manner, the principal systems and some of their characteristic fossils being described in order, beginning with the Pre-Cambrian. Special emphasis is laid upon the evolution of the North American continent and the evolution of life upon the planet.

It is probable that many will doubt the wisdom of dropping out structural geology as a special subject and treating it only in connection with geological processes. There are difficulties in the way of such a treatment, one being the danger that the elementary student will not discriminate sufficiently between the process, the structures due to the process, and the structures which merely affect the operation of the process, all of which are treated under a single tit e. In the present text this danger is minimized by a clear presentation of the different factors involved, although in places a stronger discrimination between structures due to the process under discussion and structures controlling the operation of that process might profitably have been made.

The illustrations are well chosen and remarkably good. Indeed, Professor Norton's book is one of the best illustrated elementary texts on geology which the reviewer has seen. The book is thus made attractive to the student, and at the same time the subjects treated are made more real to him than is possible with inferior illustrations. In view of the fact that contour maps are used for some of the figures, it would doubtless increase the efficiency of the book to have the printed explanation of contours on page 69 supplemented by such illustrations as would aid the student to a better understanding of that subject than the brief printed text is apt to impart

As is the case with every text, there are points in Professor Norton's book which one would prefer to see changed. But after a careful reading the reviewer is convinced that the author has succeeded in his endeavor to present a text which will rank as one of the best elementary treatises on geology. The mechanical work on the book is excellent.

D. W. JOHNSON.

PUBLICATIONS RECEIVED

From April 1 to May 1, regular exchanges not included
The year of publication, when not otherwise noted, is 1907.

BERGEN, J. Y. and DAVIS, B. M. *Laboratory and Field Manual of Botany.* Boston, Ginn & Company, 1907. 12mo, 257 pp. 90 cents.— BIGELOW, E. F. *The Spirit of Nature Study.* New York, A. S. Barnes & Company, 1907. 222 pp., illus.

APPELLÖF, A., *editor.* Meeresfauna von Bergen, parts 2 and 3 (Bryozoa and decapod Crustacea), pp. 76–233, 4 pls., 3 maps. *Publ. of the Bergen Museum*, 1906.— CHEVREUX, ED. Orchomenella lobata, nouvelle espèce d'Amphipode des régions arctiques. *Bull. de l'Inst. Oceanog. de Monaco*, no. 96, 6 pp., 3 figs.— COBB, N. A. Some elements of plant pathology. *Rep. of the Exp. Sta. of the Hawaiian Sugar Planters' Assoc., div. of path. and p ys.*, bull. 4, 46 pp., 32 illus. — COUTIÈRE, H. Questionnaire relatif aux espèces comestibles de Crustacés. *Bull. de l'Inst. Oceanog. de Monaco*, no. 98, 8 pp.— FERNALD, H. T. The San José scale and experiments for its control. *Mass. Agric. Exp. Sta.*, bull. 116, 22 pp.— FORBES, S. A. On the local distribution of certain Illinois fishes. *Bull. of Ill. State Lab.*, vol. 7. art. 8, pp. 273–303, pls. 24–32, 15 maps.— FORBES, S. A. An ornithological cross-section of Illinois in autumn. *Bull. of Ill. State Lab.*, vol. 7, art. 9, pp. 305–335.— FRANKLIN, H. J. Preliminary report on cranberry insects. *Mass. Agric. Exp. Sta.*, bull. 115, 15 pp.— GRINNELL, J. and H. W. Reptiles of Los Angeles County, California. *Throop Inst. Bull.*, no. 35, 60 pp., 23 figs. HODGE, F. W., *editor.* Handbook of American Indians north of Mexico part 1. *Smithsonian Inst., Bur. of Amer. Ethn.*, bull. 30, 972 pp., illus.— JOHANNSEN, W. Om "Kortskaller" og "Langskaller." *D. K. D. Vid. Selsk. Overs.*, no. 1, 72 pp.— JORDAN, D. S. A review of the fishes of the family Gerridae found in the waters of Japan. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 245–248, 2 figs.— KOFOID, C. A. Dinoflagellata of the San Diego region, III. Descriptions of new species. *Univ. of Cal. Publ., Zool.*, vol. 3, no. 13, pp. 299–340, pls. 22–33.— MEARNS, E. A. Mammals of the Mexican boundary of the United States, part 1. *Smithsonian Inst., U. S. Nat. Mus.*, bull. 56, 501 pp., 126 figs., 1 map.— MERRILL, G. P., and TASSIN, W. On the meteorite from Rich Mountain, Jackson County, North Carolina. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 241–244, pl. 16.— PORTER, P., and RICHARD, J. Sur une méthode de prélèvement de l'eau de mer destinée aux études bactériologiques. *Bull. de l'Inst. Oceanog. de Monaco*, no. 97, 4 pp., 4 figs.— SARS, G. O. An account of the Crustacea of Norway, vol. 5, parts 13–16 (Copepoda: Diosaccidæ and Canthocamptidæ), pp. 157–196, 32 pls.) *Publ. of the Bergen Museum*, 1906.— STARKS, E. C. and MORRIS, E. L. The marine fishes of southern California. *Univ. of Cal. Publ., Zool.*, vol. 3, no. 11, pp. 159–251, pl. 21.— VAUGHAN, T. W. Some madreporarian corals from French Somaliland, East Africa, collected by Dr. Charles Gravier. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 249–266, pl. 17–28.— VERNON, J. J. Dry farming in New Mexico. *N. M. Agric. Exp. Sta.*, bull. 61, 54 pp., 30 pls.— WILLIAMS, H. S.

A new Brachiopod, *Rensselæria mainensis*, from the Devonian of Maine. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 267–269.

ANNALES DE LA SOCIÉTÉ BELGE DE MICROSCOPIE, vol. 27, no. 2, 1906; vol. 28, no. 1. ANNUAL ANNOUNCEMENT OF THE MARINE BIOLOGICAL LABORATORY, WOODS HOLE, MASS. BERGENS MUSEUM AARBOG 1906, nos. 1 and 2. BULLETIN OF THE CHARLESTON MUSEUM, vol. 3, no. 3. BULLETIN OF THE TORREY BOTANICAL CLUB, vol. 34, no. 2. JOURNAL OF GEOGRAPHY, vol. 6, no. 1. Naturæ Novitates, vol. 29, nos. 1–3. OHIO STATE UNIVERSITY BULLETIN, vol. 11, no. 9, supplement B. PRESIDENT'S REPORT OF THE UNIVERSITY OF MONTANA, 1905–1906. PROCEEDINGS OF THE WASHINGTON ACADEMY OF SCIENCES, vol. 8, pp. I–XIII, 487–491. STATEN ISLAND ASSOCIATION OF ARTS AND SCIENCES, vol. 1, part 3, 1906, and memorial number, 1907. UNIVERSITY OF COLORADO, STUDIES, vol. 4, no. 2.

(No. 485 was issued May 21, 1907)

The first of a series of Colored Plates of the

THRUSHES

OF

NORTH AMERICA

By FUERTES & HORSFALL,

was published in BIRD-LORE for February.

The series will be concluded this year

20 CENTS A COPY. $1.00 A YEAR

THE MACMILLAN CO.

NEW YORK CITY

BERGEN'S
ELEMENTS OF BOTANY

REVISED EDITION

By JOSEPH Y. BERGEN,
Recently Instructor in Biology in the English High School, Boston

Including Key and Flora for Northern and Central States. 12mo. Cloth. 283 + 257 pages. Illustrated. List price, $1.30; mailing price, $1.45. Without Key and Flora. List price, $1.00; mailing price, $1.10.

Issued also in three special editions with a Key and Flora for each: Pacific Coast Edition, Southern States Edition, and Rocky Mountain Edition. List price, $1.30 each; mailing price, $1.45.

BERGEN'S "Elements of Botany," Revised Edition, is designed to furnish a half-year course in the subject for students in secondary schools. It covers all the ground which ordinary classes can traverse in the time indicated, and presents only those topics which are essential to an elementary course in the science.

It differs from the earlier editions of the "Elements" mainly in the greater stress laid on the topics of ecology and cryptogamic botany, in the somewhat abbreviated directions for histological work on seed plants, and in the greatly improved quality of the illustrations. Minor changes will be found on almost every page.

THE BOOK IS CHARACTERIZED

By the natural method of presentation, introducing the pupil first, as Professor Huxley recommended, to the comparatively familiar forms and processes of plant life.

By the sparing use of technical terms, employing these only when they are indispensable for the sake of clearness or of brevity.

By the treatment of the structures and the functions of plants consecutively, not in widely separated portions of the book.

By the intimate combination of laboratory work with discussion, taking pains, however, not to tell the pupil, either in words or by means of illustrations, what he is to see before he sees it for himself.

By the accuracy of the illustrations in detail, the half tones being used *only to give general effects, never for minute organs or structures*.

By the fact that four special keys and floras have been prepared to accompany the text. This allows the student in any part of the country to obtain practice in the determination of species of phanerogams, and to get a practical idea of their relationships and classification by means of a simply written and inexpensive flora of his own region.

BOTANY NOTEBOOK

To accompany Bergen's Text-Books on Botany, and for general use in Botanical Laboratories or for Secondary Schools. Square 4to. Cloth. 144 pages. List price, 45 cents; mailing price, 60 cents.

BERGEN'S Notebook was prepared with the particular view of minimizing the amount of routine dictation for both teacher and pupil without doing any of the latter's thinking for him. Not only will it save time and trouble, but it will also lead the pupil to perform neat and accurate work.

GINN & COMPANY PUBLISHERS

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS
WILLIAM E. CASTLE
EDWIN G. CONKLIN
CHARLES B. DAVENPORT
HERBERT S. JENNINGS
FRANK R. LILLIE
JACQUES LOEB
THOMAS H. MORGAN
GEORGE H. PARKER
CHARLES O. WHITMAN
EDMUND B. WILSON

ROSS G. HARRISON, Managing Editor

CONTENTS OF VOLUME IV

NO. 1, FEBRUARY, 1907

Abnormal Development of Toad Ova Fertilized by Spermatozoa Exposed to the Roentgen Rays . . . . . Charles R. Bardeen
An Ecological and Experimental Study of Sarcophagdae with Relation to Lake Debris . . . . . William B. Herms
Rejuvenescence as the Result of Conjugation . . . . . Sara White Cull
Artificial Parthenogenesis in Thalmessema Mellita . . . . George Lefevre
Concerning the Theory of Tropisms . . . . . Jacques Loeb
The Mechanism of the Galvanotropic Orientation in Volvox Frank W. Bancroft

NO. 2, MAY, 1907

The Influence of External Factors, Chemical and Physical, on the Development of Fundulus Heteroclitus . . . . Charles R. Stockard
The Energy of Segmentation . . . . . Edward G. Spaulding
Movement and Problem Solving in Ophuria Brevispina . . . Otto C. Glaser
The Occurrence of a Sport in Lina Lappomica and its Behavior in Heredity . . . . . Isabel McCracken
Experiments in Transplanting Limbs and Their Bearing upon the Problems of the Development of Nerves . . . . . Ross G. Harrison
Factors in the Regeneration of a Compound Hydroid, Eudendrium ramosum . . . . . A. J. Goldfarb

PRICE OF SUBSCRIPTION PER VOLUME

(PAYABLE IN ADVANCE)

To subscribers in the United States, Canada and Mexico	$5.00
To subscribers in other countries	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to the Journal of Experimental Zoology

ADDRESS ALL COMMUNICATIONS TO

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

N. E. Cor. Wolfe and Monument Streets

BALTIMORE, MD., U. S. A.

For Summer Reading

What could be better than a Three-Months' Trial Subscription to

The Living Age?

One dollar will bring you this Magazine every week for three months

Containing

THE BEST FICTION
THE BEST ESSAYS
THE BEST LITERARY CRITICISM
THE BEST TRAVEL ARTICLES
THE ABLEST DISCUSSIONS OF PUBLIC AFFAIRS

With the whole range of contemporary English periodicals from the Quarterlies to Punch, to select from, THE LIVING AGE is able to give its readers every week a larger variety of material written by the most brilliant writers than any other single magazine.

THE LIVING AGE has been published every Saturday without missing an issue for more than 63 years and was never more indispensable than now to intelligent readers.

TERMS: SIX DOLLARS A YEAR

Three-Months' Trial Subscription one dollar

The Living Age Company

6 BEACON STREET, BOSTON

VOL. XLI, NO. 487 JULY, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	Agassiz Centennial. Remarks by	CHARLES W. ELIOT	413
II.	Description of a New Species of Telenomus with observations on its Habits and Life History	A. W. MORRILL	417
III.	The Development of Pinnate Leaves	FREDERIC T. LEWIS	431
IV.	Contributions to the Pleistocene Flora of Canada	D. P. PENHALLOW	443
V.	Significant Results of a Decade's Study of the Tunicata.	WILLIAM E. RITTER	453
VI.	Notes and Literature: *General Biology;* The Agassiz Centennial.—The preservation of native animals and plants. *Zoology;* The curious mating habit of the fly *Rivellia boscii*—The spermatophores of Salamandra.—Stone-gathering fishes. *Botany;* The search for mutations.— Biology in the *Journal of Agricultural Science.*—Notes		461
VII.	Publications Received		475

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.Sc., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology, Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *July, 1907* No. 487

AGASSIZ CENTENNIAL

REMARKS OF

CHARLES WILLIAM ELIOT

LADIES and Gentlemen: Mr. Dana in opening this meeting spoke of the Saturday Club and of Agassiz as a member. His words reminded me of the only occasion when I ever heard a speech made at that Club. I have been a member of it now about thirty-five years, and only on this one occasion did I ever hear a speech made there. It was when Agassiz, who at that time always sat at the foot of the table, was going away on that long voyage of the Hassler round Cape Horn. At the head of the table sat Longfellow, as usual, and along the sides sat many of the men just mentioned by Mr. Dana. Near the close of the dinner Longfellow suddenly rose, and to our great astonishment said,—"Our dear friend Agassiz is going away; he is going on a long voyage in the hope of recovering his health; we shall miss him grievously; we shall welcome him back most thankfully, restored to health. Let us drink his health now." And we all got up except Agassiz, and drank his health; and then he rose and struggled to say something, and could not; and finally the tears rolled down his cheeks and he sat down speechless. It was a vivid instance of a characteristic quality in Agassiz, namely, the strength of his emotions. He was a man of strong and deep emotions, and his influence over us restrained, reserved Americans was largely due to the intensity of his feelings, and to the way in which his face and body expressed those feelings.

He was, as has been repeatedly said here this evening, a born

teacher and expositor. He expounded clearly and sympathetically before any audience the fundamental principles of his science, and gave examples illustrating the principles with both hands, and with shining, smiling face. He was just that,— a teacher by nature, an enthusiastic, earnest, moving teacher.

As Professor Gray has just said, he came into this Puritan society like a warm glow into a chilly room. He was a revolutionary spirit in Harvard College, an exception to all our rules. He welcomed special students, for instance, who could not possibly pass the examinations for admission to Harvard College. He kept them for years in his laboratory, training them in his observational method,— quite a new introduction among us. Many of our best people disapproved of that method! The son of one of our most distinguished surgeons submitted himself to the teaching of Agassiz in the crude zoölogical laboratory, and received several trilobites upon which he was expected to spend weeks,— examining them, seeing what he could discover in them, and making a record of his discoveries. He was kept at this sort of work for weeks without a book, and without plates. He was to make his own plates. At last the son described this process to the father as novel and interesting, but difficult. Now that father was at bottom a naturalist, like every physician or surgeon, and yet he said,— "What! no book, no plates, no guidance from the wisdom of all preceding generations! Set just to use your own senses on those fossils!" "Yes," said the son, "that was the whole of it." "Well," said the father, "that is exactly the way a puppy has to learn everything." The criticism was a real one; the father thought that Agassiz was neglecting all the natural and proper aids which past time had placed at the service of human youth.

And then, what a new kind of professor Agassiz was in this old town! He had none of the regular habits of the traditional Harvard professor. He did not even wear the characteristic black clothes. He would cross the College Yard any day of the week, at any hour of the day, in a soft, grey felt hat, smoking a cigar when to smoke in the College Yard was a grave offence. He never went to church. Sunday was his day of rest, but he did not take it in the New England fashion. His mode of lecturing was

unexampled among us. His conception of the duty of a professor to investigate, to discover, to collect, we had only noticed faintly in a few exceptional American teachers. Those methods had been introduced in small measure among us; but those were the prime ideas of Agassiz as a professor and a teacher.

There were but two pitiful little collections in the possession of the University when Agassiz first came here,— a collection of minerals, imperfect, small, and never properly arranged, and the beginnings of a botanic garden and herbarium. The idea of making great collections of natural history objects hardly existed among us; we had hardly aspired to such collections.

And then, he raised such astonishing sums of money for these new subjects of zoölogy and geology. A good deal of jealousy about this extraordinary money-raising was felt by members of other departments long established in Cambridge for the traditional subjects of collegiate instruction. I remember one night at my uncle Mr. George Ticknor's, hearing this jealousy expressed by one of Professor Agassiz's colleagues in Harvard University. But Mr. Ticknor said,— "Don't be alarmed; Agassiz will get more money out of the Commonwealth of Massachusetts for his subjects than any of you have dreamed of getting, than any of you could possibly get; but he will so equip his subject, he will set such a standard for collections in all subjects, that every department of learning in the University will profit by his achievements." That is just what has turned out to be the truth.

Agassiz founded here an institution; and he has had this unusual felicity,— that his son, an extraordinary naturalist and an extraordinary man of business, has built up with prodigious skill and liberality the institution which his father founded. That, I say, is a rare felicity.

Every teacher who is eminently successful as teacher, inspirer, and enthusiast, wins another sort of felicity in time. He brings up a group of disciples, and these disciples carry their master's teaching beyond their master's own range, and adapt his teachings to the new conditions which rapidly come about in science,— indeed, in all kinds of learning and working, and in modern society as a whole. That felicity Agassiz has enjoyed,— a beautiful felicity, a rare reward.

So we welcome this commemoration of a great teacher and a noble friend, and we say with Longfellow at the Saturday Club,—We miss him greatly, but we rejoice in his coming back to us in durable memory, and in the infinite ramifications of his personal influence.

Cambridge. 27 May '07

DESCRIPTION OF A NEW SPECIES OF TELENOMUS WITH OBSERVATIONS ON ITS HABITS AND LIFE HISTORY

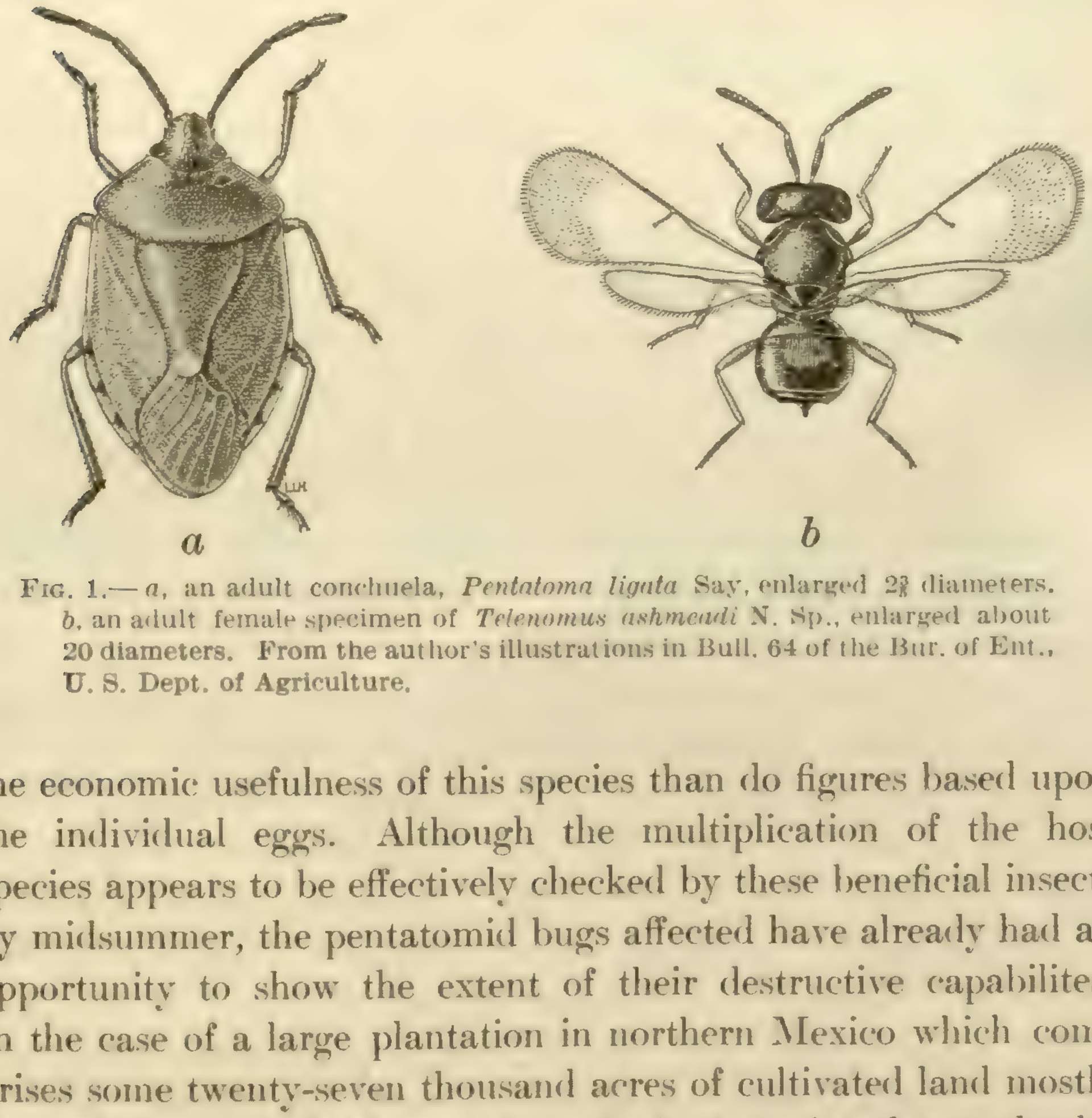
A. W. MORRILL

Minute egg parasites belonging to the hymenopterous family Proctotrypidæ are known to play an important role in checking the multiplication of certain insects, fluctuations in the numbers of the parasites and hosts usually being intimately associated and resulting in a corresponding benefit or injury to the crops attacked by the latter. Notwithstanding the economic importance of the proctotrypids our knowledge of their life histories is very meager, and the incidental and more or less fragmentary notes upon which this contribution is based seem to point to a fruitful field for the investigator.

The data here presented were obtained in 1905 in connection with the investigation of heteropterous pests of cotton, alfalfa and other crops. The principal insect (Fig. 1, *a*) affected by the parasite here discussed, is a member of the stink-bug family or Pentatomidæ, and is commonly known in Mexico by the name "Conchuela." Only five North American species of proctotrypids known to attack the eggs of these bugs have heretofore been described, but many undescribed forms doubtless exist. All of these five species were described by Ashmead ('93), one belonging to the genus Telenomus and four to Trissolcus.

H. A. Morgan ('97) records that in Louisiana in August, 1896, the eggs of the Harlequin Cabbage Bug, *Murgantia histrionica*, were parasitized by proctotrypids (*Trissolcus murgantiæ* and *Trissolcus podisi*) to the extent of over 60%. The writer has noted ('07) that of 211 pentatomid eggs collected at Barstow, Texas, in September 1905, 148 or 70% produced adult specimens of *Telenomus ashmeadi*, the species hereafter described. During July 1905, 22 batches including 794 eggs were collected in cotton and alfalfa fields at Tlahualilo, Dgo., Mexico. Of these, 18 batches were parasitized and from their 638 eggs, 468 adult speci-

mens of *Telenomus ashmeadi* were produced. The remaining eggs, amounting to 27%, failed to produce adult parasites or to hatch; they were presumably destroyed by parasites which failed to mature or to emerge, for from the four non-parasitized egg batches 155 bug nymphs hatched from 156 eggs. In the case of every parasitized pentatomid egg batch collected at Barstow, Texas, or at Tlahualilo, Mexico, no nymphs hatched, showing that in the majority of cases complete destruction results whenever an egg batch of a host species is discovered by its tiny enemies. Of 41 batches collected, 36 or 88% were parasitized by *Telenomus ashmeadi*. This probably represents more closely



a *b*

FIG. 1.—*a*, an adult conchuela, *Pentatoma ligata* Say, enlarged 2⅜ diameters. *b*, an adult female specimen of *Telenomus ashmeadi* N. Sp., enlarged about 20 diameters. From the author's illustrations in Bull. 64 of the Bur. of Ent., U. S. Dept. of Agriculture.

the economic usefulness of this species than do figures based upon the individual eggs. Although the multiplication of the host species appears to be effectively checked by these beneficial insects by midsummer, the pentatomid bugs affected have already had an opportunity to show the extent of their destructive capabilites. In the case of a large plantation in northern Mexico which comprises some twenty-seven thousand acres of cultivated land mostly devoted to cotton, the damage from the host species, the conchuela, is estimated at from twenty to sixty thousand dollars in single seasons. Without the natural check afforded by these parasites this destruction would doubtless be increased five or six times.

Description and Records of Breeding and Collection.

This parasite having been pronounced a new species of the genus Telenomus by Dr. W. H. Ashmead, the writer takes pleasure in dedicating it to this eminent authority on the parasitic Hymenoptera who has described more than 500 North American representatives of the family Proctotrypidæ.

Telenomus ashmeadi, N. Sp. ♀ (Fig. 1, *b*). Length 1.08–1.15 mm. Black with fine pale pubescence.

Head.— Width, .56 mm., scarcely wider than thorax, marked with impressed reticulations; mandibles black. Antennæ clothed with pale pubescence, dark brown to blackish in color, except pedicel the color of which gradually changes to light brown at distal end. Proportionate dimensions of antennal segments (Fig. 2, *B*) are as follows:[1]

	Scape	Pedicel	Segments of Flagellum									
	:	:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*1–9*
Length	105	28	30	18	12	11	17	15	15	16	20	124
Greatest width	16	12	11	11	13	15	18	18	17	16	13	——

Thorax.— Width .55 mm., length .48 mm. Dorsum marked with impressed reticulations, pubescent; mesoscutum rather roughly longitudinally grooved posteriorly; scutellum smooth and shining with a few pale hairs arising from minute punctures. Legs clothed with moderately dense pale pubescence; coxæ black; trochanters, tibiæ and tarsæ light brown by reflected light, yellowish brown by transmitted light; tarsal segments successively darker to the last; femora dark brown or brownish black by reflected light, dark brown by transmitted light. Proportionate length of segments of hind tarsæ not including tarsal claws, as follows:[2] $\frac{1}{13}$, $\frac{2}{6}$, $\frac{3}{4}$, $\frac{4}{3}$, $\frac{5}{4}$. Wings hyaline, iridescent; venation brownish; length of fore wing 1 mm., greatest width, .46 mm.

Abdomen.— Length .532 mm., width .518 mm.; basal two thirds of first segment striate above; basal two thirds of second

[1] Measurements made with 1 in. eye piece and $\frac{1}{6}$ in. obj.; tube length 160 mm. To obtain dimensions in mm. multiply by .003.

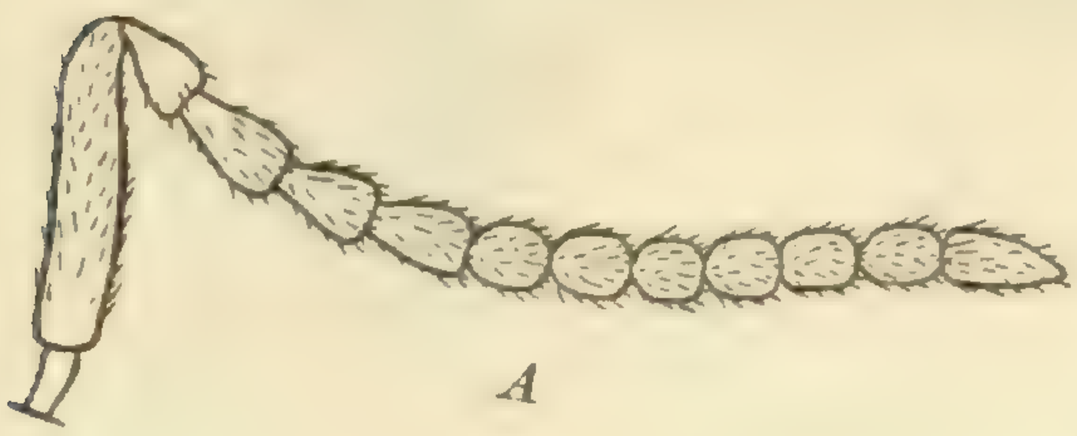
[2] Measurements made with 1 in. eye piece and $\frac{2}{3}$ in. obj., tube length 160 mm. To obtain true lengths in mm. multiply by .0148.

segment striate above except laterally, elsewhere smooth and shining; third to fifth segments punctate. Length of second segment .3 mm., greatest width .518 mm. Second, third and fourth segments fringed with sparse pale hairs posteriorly. Fifth segment finely pubescent. Ventral plates finely punctate and pubescent. Sheath of ovipositor about .044 mm. in length. Ovipositor when fully extended about .1 mm. in length.

♂.— Length .8–1.13 mm. Differs in form from the female principally in the moniliform twelve segmented antennæ and the more abruptly truncate abdomen. Head, .44–.62 mm. wide. Thorax, .38–.55 mm. wide. Length of abdomen .32–.44 mm., greatest width .38–.46 mm. Proportionate dimensions of antennal segments (Fig. 2, *A*) are as follows:[1]

	Scape	Pedicel	Segments of Flagellum										
	:	:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*1–10*
Length	100	25	31	24	25	20	19	19	19	19	20	30	226
Greatest width	17	15	17	17	17	17	17	17	16	15	15	14	—

The constricted basal portion of the scape is dark brown; the outer three-fourths is light brown. Pedicel light brown, darker on outer side. Flagellum light brown basally, changing to dark brown distally. Legs except the coxæ light brown in color by reflected light, by transmitted light pale brown to honey yellow.



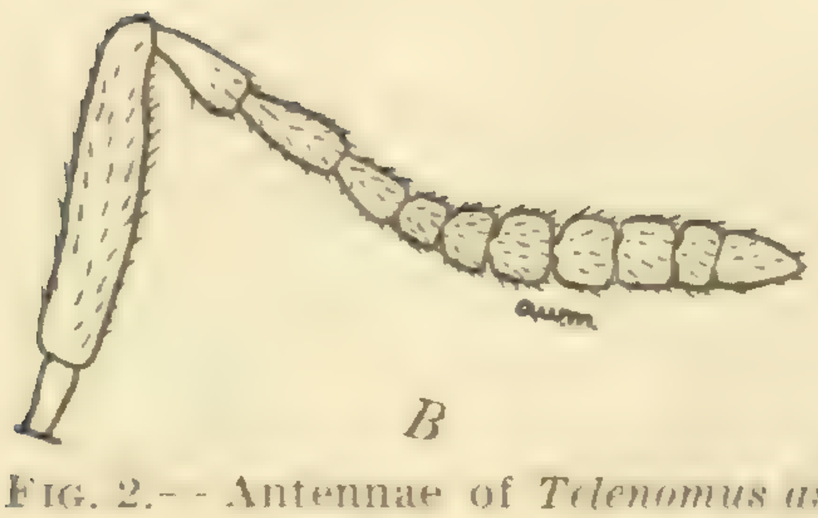


FIG. 2.— Antennae of *Telenomus ashmeadi*, enlarged 70 diameters. *A*, male. *B*, female.

Described from numerous specimens of both sexes. Cotypes deposited in the U. S. National Museum; Type No. 10364. Type locality Barstow, Texas; also collected at Tlahualilo, Dgo., Mexico.

[1] Measurements with same combination as used for measurements of the segments of the antennæ in the female. Multiplying the figures by .003 will give dimensions in mm. of average specimens bred from eggs of *Pentatoma ligata*.

All of the females were bred from eggs of *Pentatoma ligata* collected at Barstow, Texas, Sept. 12th, 1905. Three of the males were bred from eggs of *Thyanta custator* Fabr. In the foregoing description of the male, the smaller series of dimensions refers to the specimens bred from *Thyanta custator*, and the larger series of dimensions to specimens bred from the eggs of *Pentatoma ligata*. It is probable that this parasite will readily attack the eggs of most or all of the species of pentatomid bugs. In addition to the eggs of *Pentatoma ligata* they have been bred from the eggs of *Pentatoma sayi* Stal collected at Barstow and in the laboratory showed no hesitation in attacking the eggs of *Euschistus servus* Say and *Thyanta custator*. The size of the adult parasites corresponds directly with the size of the respective host eggs. The following table showing the relationship between the size of the host eggs and of the adult parasites is based on five male specimens bred from eggs of each of the three host species:

Host species	Pentatoma ligata	Euschistus servus	Thyanta custator
Host egg, average length	1.33	1.11	.90
" " , average diameter	1.01	.88	.75
Head of parasite, average width	.60	.53	.45
" " " , maximum width	.62	.54	.47
" " " , minimum width	.56	.52	.44

The parasitizing of eggs of pentatomid species representing more than one genus by a proctotrypid was recorded in 1897 by Prof. H. A. Morgan who bred *Trissolcus podisi* from the eggs of *Murgantia histrionica*, the Harlequin Cabbage Bug. The parasite in this case had previously been recorded as having been bred from the eggs of *Podisus maculiventris* Say (= *spinosus* Dal).

Habits and Life History.

Emergence of adults. The adult parasites use their mandibles to make exit holes for themselves at the top of the eggs, i. e., at the end through which the nymphs normally emerge (Fig. 3). When mature, the parasite completely fills the host egg and so far as observed always develops with its head at the end from which the pentatomid nymphs normally hatch. In one instance, one egg of a batch of 28 was deposited wrong side up by the parent

pentatomid (*P. ligata*) and after the batch was subsequently parasitized the adult proctotrypid emerged from the top side of the misplaced egg, *i. e.*, the under side of the egg batch.

Oviposition. On one occasion it was observed that four adult parasites, which had previously been rather quiet at the top of a cage, became very much excited immediately upon the introduction of empty egg shells of *Thyanta custator* and an unhatched egg batch of *Euschistus servus*. The insects were not ordinarily dis-

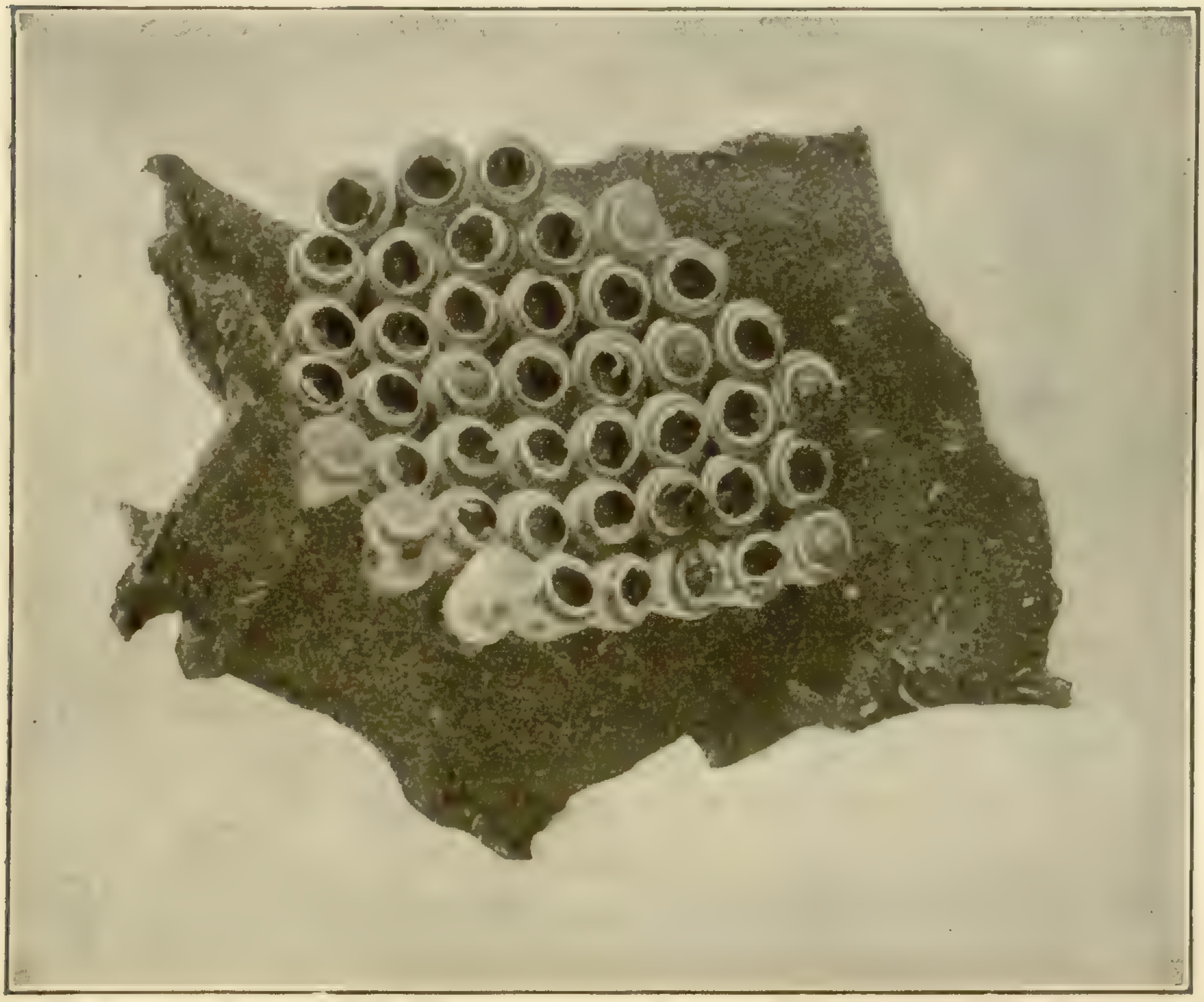


FIG. 3.— Egg batch of conchuela, *Pentatoma ligata*, from which 32 parasites, *Telenomus ashmeadi*, have emerged. Enlarged 6¾ diameters. The illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant. Morrill, Bull. 64 of the Bureau of Entomology, United States Department of Agriculture.

turbed by such a slight movement of the cage as was necessary to introduce these eggs and egg shells, but in this case they dropped almost at once to the bottom and carefully examined the empty egg shells, after which the eggs of *Euschistus servus* were found, and oviposition in these began almost immediately. At another time thirteen parasites, presumably all females, showed similar excitement upon the introduction of eggs of *Pentatoma ligata*.

No attempt was made to ascertain the nature of the tropism or sense which leads to the discovery of host eggs by the adult parasites, but it appears that the attraction is as great for empty egg shells of *Thyanta custator* as for unhatched eggs of *Euschistus servus* in a suitable stage of development for successful parasitism.

When the pentatomid egg batch is found, the adult parasite carefully examines it with her antennæ. If the eggs are satisfactory she sets to work industriously and oviposits in one egg after the other. The process of oviposition in a single host egg requires from two and one quarter to three minutes. The body of the female during this operation is held rigidly by the legs in a position nearly perpendicular to the surface of the host egg at the point of introduction of the ovipositor. The puncture may be made through the egg cap or top end of the egg, or it may be through the side of the egg. The latter is more frequently the case with eggs located on the outside of the batch.

Before leaving the egg the female scrapes it for a few seconds with the tip of the ovipositor, usually moving it around the point of insertion making a nearly complete circle, then reversing and with a shorter radius passing around to or beyond the starting point, then perhaps reversing again and with a still shorter radius making a nearly complete circle. Sometimes a much more irregular figure is traced but it is always curved for the most part, and so far as observed the direction of the movement is abruptly reversed from one to three times. It is difficult to imagine any useful purpose of this instinctive act except to mark the parasitized egg so that it can be detected as unsuitable for further attack by parasites of its own and probably other species.

Egg laying capacity. The largest number of pentatomid eggs positively known to have been successfully parasitized by a single female of the species here considered is 27. The total number of eggs which a female parasite may deposit appears not to be necessarily indicated by the number of adult parasites which may result. In many cases it has been found that the parasite for some reason failed to emerge even after reaching full maturity. In other cases the larvæ of the parasites appear to die when quite young, although accomplishing the destruction of the host egg. The data at hand on the number of eggs deposited by a single female parasite of this species are given in the following table:

NUMBER OF PENTATOMID EGGS PARASITIZED BY SINGLE SPECIMENS OF *Telenomus ashmeadi*.

Date 1905	No. of eggs accessible	No. of eggs from which adult parasites were bred	No. failing to hatch or to produce adult parasites; probably parasitized
July 17	28	27	1
" 28	42	21	7
Sept. 16	127	13	34
" 30	13	13	0
" 30	10	10	0
" 30	22	22	0

Developmental period of the parasite compared with the incubation period of the host. The parasite requires for its complete development about twice the normal incubation period of the host egg at any given temperature. The following table summarizes the data at hand which bear on this point:

DEVELOPMENTAL PERIOD OF PARASITES AND INCUBATION PERIOD OF EGGS OF THE HOST SPECIES.

When parasitized	Locality	Developmental period of parasite days.	hrs.	Aver. daily mean temperature °F	Incubation period of non-parasitized host eggs days.	hrs.
July 17, 6 P. M.	Tlahualilo, Mexico	10	23	80.2	5	1
Sept. 16, 10 A. M.	Dallas, Texas	11		76.	5	11
Sept. 24, 10 A. M.-5 P. M.	" "	11	12	74.	6	—
Sept. 28-29, 4 P. M.-4 P. M.	" "	15	—	—	–	—
Sept. 30, 4 P. M.	" "	14		69.8	7	6
Sept. 30-Oct. 1, 10 A. M.-4 P. M.	" "	14		—	–	–

In the case of the first, second and fifth records the exact time of the beginning of oviposition is given to the nearest hour. In the remaining records no note was made as to the exact time at which oviposition began. The last five records, although made at Dallas, Texas, refer to specimens of host and parasite originally from Barstow, Texas. The short incubation period in the record in Mexico as compared with subsequent records in Texas is probably due to the natural adaptation of the species to climatic conditions within its range. The parasite seems to be equally well adapted to its different environments inasmuch as the relation of its developmental stages to the normal incubation period of

the eggs of the host species remains quite constant as shown in the table.

Condition of host eggs necessary for successful parasitism. In the many cases in which definite records have been made, parasitism by *Telenomus ashmeadi* has been successful with the majority of the eggs of a batch up to the time that the embryos have gone through one half of their development. The failure to produce adult parasites from the remaining eggs in such cases is probably due to some other factor than the developmental condition of the host egg.

In one instance a batch of twenty-two eggs of *Pentatoma ligata* deposited on the morning of September 26th was parasitized by a female *Telenomus* on the morning of September 30th. The normal incubation period of the eggs of the host species at this season was about six and one half or seven days, the embryos therefore at the time of oviposition were slightly more than one half developed. Twenty-one of a total of twenty-two of the bug eggs hatched in a normal manner and the remaining egg failed to produce either a nymph or an adult parasite. A similar experiment with the eggs of *Euschistus servus* deposited four days previously and at a time when the normal incubation period was about seven days resulted in four eggs of a batch of ten producing adult parasites. The remaining six eggs contained parasites which failed to emerge, perhaps as a result of an attempt to delay their emergence by placing the egg batch for a few days in an ice box.

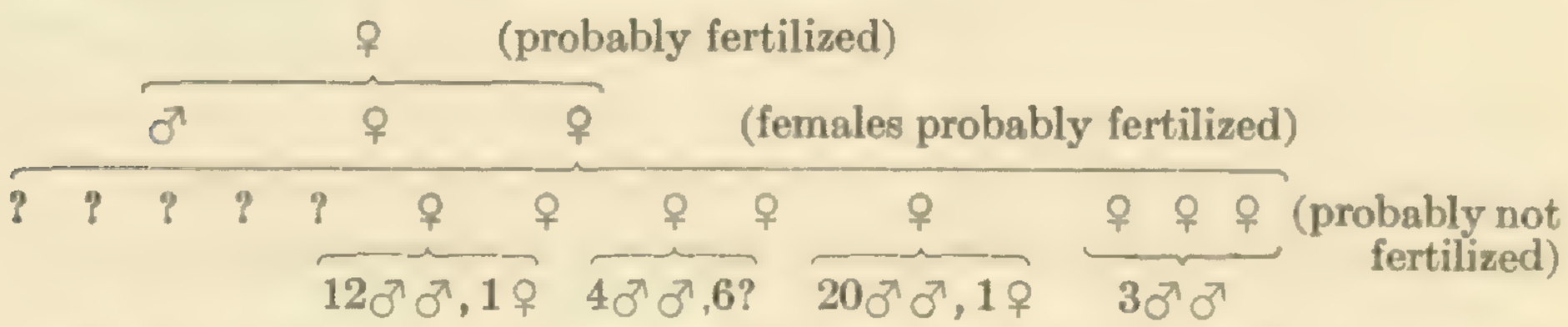
Changes in the appearance of parasitized eggs. During the course of two or three days following oviposition by the parasite the eggs of *Pentatoma ligata*, *Pentatoma sayi*, and *Thyanta custator* became slightly darker, but as they are subject to a variation in their color during normal development, parasitism cannot be said to produce any characteristic changes in appearance up to the time the adult parasites emerge. In the case of *Euschistus servus*, however, parasitism produces a marked change in color, since the egg membrane in this case is more translucent than with the other species mentioned, and the young nymphs are normally paler in color. Ten eggs of this host species were parasitized on October 1st, beginning at 3:00 P. M. On October 5th at 9:00 P. M. it was noted that seven of the ten were very dark in color, six being very dark gray and one slate gray; the three others had

changed color only slightly if at all. Two days later the eggs which had changed but little up to the time of the previous examination were as dark as the rest and indistinguishable from them as far as appearance was concerned. Parasites developed to maturity in each of these ten eggs and the first one was noted to have emerged at noon on October 16th.

Development in infertile host eggs. It is the writer's observation that shriveling of the eggs of pentatomid bugs indicates infertility although in some species, as in that of the Harlequin Cabbage Bug (*Murgantia histrionica*), a slight shrinking normally occurs just before hatching. With this as guide for the experiment, a batch of ten eggs was selected, which had been deposited by a specimen of *Euschistus servus* which previously had deposited a batch of infertile eggs. Four of these eggs were reserved as controls and a female parasite was given access to the remaining six; after having made the usual examination she was observed to begin oviposition. The four control eggs shrivelled in the course of a few days, but the six eggs into which the parasite had oviposited became dark in color and to all appearances promised to produce adult parasites. None appeared however nor did shrinking occur, and several weeks later when the eggs were opened their contents was found to consist of a very dark colored vitelline membrane together with a small shrivelled blackish mass on one side, which was unrecognizable as insect remains. A similar condition was found occasionally in parasitized eggs believed to be fertile and belonging to a batch from which many adult parasites appeared. The failure to produce adult parasites from the eggs used in the above experiment is therefore not positive evidence that this was due to infertility of the host eggs. The experiment shows however in a fairly conclusive manner that adult females of the species of proctotrypid here considered will readily parasitize infertile pentatomid eggs, and that the resulting larval parasites will develop sufficiently to cause the host eggs to take on the characteristic color of parasitized fertile eggs.

Parthenogenesis and its relation to sex of offspring. No absolute proof of parthenogenetic development of the eggs of *Telenomus ashmeadi* was obtained, but the contributary evidence from the few breeding experiments undertaken furnishes a good basis for the supposition that parthenogenetic development occurs and

moreover has a marked influence on the sex of the offspring. The following diagram shows the history of the offspring of a single female, which was one of a lot of 120 females and 19 males bred from eggs of pentatomids collected at Barstow, September 12, 1905:



The specimens recorded in the diagram by a " ?" escaped or were otherwise lost so that their sex is unknown. The last generation included eighteen specimens which are not indicated in the diagram, since they came from eggs laid before the individuals of the preceding generation had been separated from one another. Of these eighteen, fourteen were males, and the others escaped before their sex had been determined. Two females bred to maturity in the laboratory under conditions which allowed of less doubt concerning their supposed infertility, oviposited in eggs of *Pentatoma ligata* and produced 27 and 21 adult parasites respectively; of these 17 and 15 respectively were males and the remainder escaped before their sex was determined. To summarize:— The offspring of the probably fertile females numbered 10 females, 1 male, and 5 undetermined; the offspring of the probably infertile females numbered 93 males, 2 females,[1] and 26 undetermined.

Proportion of sexes in nature. This subject furnishes additional and probably the strongest evidence that the fertility or infertility of the eggs of the parasite determines to a great extent the sex of the offspring. Sixteen females and 8 males were bred from a batch of eggs of *Pentatoma ligata* collected in a cotton field at Tlahualilo, in July, 1905. Another batch yielded 20 females and 2 males. Pentatomid eggs collected at Barstow in the months of August and September, 1905, produced 125 females and 19 males. In all, of 190 adult parasites bred from pentatomid eggs collected in the field, 161 or 85% were females, and 15% males.

[1] The writer has followed his original notes closely, although at present inclined to doubt that the two females referred to above were actually bred from the same egg batches with the males. Owing to their minute size and consequent difficulties met with in handling them it seems not impossible that the two specimens were in some way misplaced.

In the laboratory, where the chances of the females becoming fertilized were much less than in nature, the sex of 106 specimens was determined as above stated; of these 11 % were females and 89% males.

Longevity and Food Requirements. Under laboratory conditions, confined in glass tubes, pill boxes and insect cages, the adult parasites under observation had an average life of 3.8 days. The maximum longevity under these conditions was 8 days. The following table shows the various records in their relation to the season of the year:

LONGEVITY OF ADULTS OF *Telenomus ashmeadi* IN THE LABORATORY.

Period	No. of adult parasites	Approximate total no. of days lived	Average longevity per specimen
July 17–20	1	3	3
" 28–31	19	47	2.4
Sept. 14–16	1	2	2
" 27–Oct. 1	3	12	4
" 27– " 2	3	15	5
" 27– " 3	1	5.5	5.5
Oct. 5– " 13	38	165	4.3

An attempt to produce artificial hibernating conditions in an ice box was unsuccessful although the adult life of each of the 25 parasites used in the experiment was very much prolonged. When subjected to an average and only slightly varying temperature of 48.6° F., one adult lived 22 days, another 21 days, and the remainder between 12 and 20 days. At the temperature mentioned the adults appeared to be entirely inactive.

Adults of *Telenomus ashmeadi* have never been observed to feed. Those upon which the observations recorded in this paper were made had no access to anything that might have been used as food except pentatomid eggs and egg shells, fragments of more or less dried cotton leaves to which such egg batches were attached, and dry cotton lint or cloth which was used to close the tubes or cages in which the parasites were confined. No moisture was accessible to any of those which were used in the breeding experiments. In biting the exit holes from the host eggs the fragments of the egg shells are not eaten by the parasites. The evidence indicates that the parasites are sufficiently nourished

during their larval existence to require no food for carrying on, at least to a certain extent, their reproductive functions. It is not unlikely, however, that their longevity and reproductive capacity is increased by such food as they might obtain under natural conditions.

Summary and Conclusions.

1. A species of the proctotrypid genus Telenomus, believed to be new, is described under the name *Telenomus ashmeadi*.

2. The species, although originally bred from the eggs of pentatomid bugs of the genus Pentatoma, readily attacks the eggs of species of the genera Thyanta and Euschistus and such eggs ordinarily produce adult parasites differing in size from the parent in direct correspondence with the size of the host eggs.

3. The developing parasite invariably occupies a fixed position in relation to the embryo of the host, and emerges from the egg through the end from which the bug nymph normally hatches.

4. Adult female parasites are capable of detecting the presence of pentatomid eggs at some distance; four specimens were as strongly attracted by empty egg shells as by the unhatched eggs suitable for parasitizing.

5. Between two and three minutes are required for oviposition, after which the surface of the host egg is marked by the ovipositor in a characteristic manner, presumably for aiding in its subsequent detection as unsuitable for attack by other parasites.

6. The maximum number of pentatomid eggs known to have been successfully parasitized by a single specimen of *Telenomus ashmeadi* is 27; but there is evidence that this number may be greatly exceeded.

7. The entire developmental period of the proctotrypid parasite here considered is approximately twice the normal incubation period of the eggs of the host species, in Texas and northern Mexico during the summer months of 1905 varying approximately from 11 to 15 days.

8. Pentatomid eggs may be parasitized successfully by *Telenomus ashmeadi* up to the time that the host embryos have passed through one half of their incubation period. After this time the results are uncertain.

9. Pentatomid eggs with translucent membranes containing developing nymphs of a pale color undergo a characteristic darkening as a result of the parasitism. Other eggs with more opaque membranes and dark colored developing nymphs do not exhibit characteristic changes in external appearance.

10. Females of *Telenomus ashmeadi* show no hesitation in ovipositing in infertile pentatomid eggs, and such eggs when parasitized do not show the shrinkage which is usual in infertile eggs. In the case of *Euschistus servus* they undergo the changes in color characteristic of the parasitized fertile eggs of this species. Although no adults have thus far been bred from parasitized infertile eggs, the development of the parasite is at least partial, and the observations here recorded furnish only slight evidence that complete development in infertile host eggs is impossible.

11. Sex of the offspring seems to be controlled to a great extent, if not absolutely, by fertilization. In nature where the chance for a female parent to be fertilized is at a maximum the female sex greatly predominates, whereas under laboratory conditions which artificially reduce the chances for mating of the adults, the male sex predominates in an even greater proportion.

12. In confinement in the laboratory, adult life under ordinary temperature conditions lasts but a few days. The maximum period recorded during the month of July is three days, during September four days, and during October eight days.

13. The adults of *Telenomus ashmeadi* have not been observed to feed and apparently this is not necessary for carrying on reproductive functions.

WASHINGTON, D. C.

BIBLIOGRAPHY.

ASHMEAD, W. H.
1893. A monograph of the North American Proctotrypidæ. *U. S. Nat. Mus.*, bull. 45.

MORGAN, H. A.
1897. Report of the entomologist. *Louisiana Agric. Exp. Station* bull. 48.

MORRILL, A. W.
1907. The Mexican conchuela in western Texas in 1905. *U. S. Dep. of Agric., Bur. of Ent.*, bull. 64, pt. 1.

THE DEVELOPMENT OF PINNATE LEAVES

FREDERIC T. LEWIS

Between 1837 and 1861 the development of leaves occasioned a lively controversy among botanists. Schleiden's school maintained that a leaf grows at its base,— not at its tip, and that this is the fundamental distinction between leaf and branch. Basal growth was demonstrated by painting the outer half of a young leaf and observing the diminishing proportion of the painted area as the leaf grew; it was also observed that many actively growing leaves of monocotyledons were dead and withered at their distal ends. The leaflets of compound leaves were thought to arise at the base and to be pushed outward so that the stipules and basal leaflets of the mature leaf were the last of all parts to appear. Contrary to all this Nägeli declared that the stipules are formed first, and that lateral leaflets are cut off from the terminal leaflet so that the apical lateral leaflets are the youngest. Since the basal part of the leaf forms first and grows longest it becomes the broadest part, but the growing tip remains slender. In 1861 Eichler introduced his thorough study of leaf development with the statement, "The nature and development of leaves have been a subject of controversy among botanists until recent times, and the issue is still undecided." Since then, however, the attention of investigators has been directed chiefly to newer problems, and the subject remains about as Eichler left it. Ten years ago, quite unaware of this controversy, the writer gathered and sketched a selection of mature rose, blackberry, and sumac leaves which presented the problem in very clear terms. In the present paper some of these leaves are to be described, after which the embryological interpretation of their peculiarities will be considered, and finally their evolutionary significance will be noted.

Mature Leaves.— The group of rose leaves (Fig. 1) was gathered from different bushes and from various parts of the stem. Although they all probably came from *Rosa lucida* Ehrh., other species of wild rose may be included. The arrangement of the leaves is

purely arbitrary, but it indicates a possible mode of development. The lower pair of leaflets in *b* is close to the stipules; in *c* and *d* the length of petiole separating them from the stipules is successively greater. In *e* one stipule is enlarged and leaf-like at its tip, having a coarsely serrate upper margin and containing a mid-rib; in *f* there is a complete leaflet close to the stipule. *G*, *h* and *i* show an imperfectly developed pair of leaflets in relation with the stipules. *J* and *k* have a perfect pair close to the stipules, and in *l* and *m* this third pair is more distally placed since the petiole is longer. Thus the series suggests that the third pair of leaflets is developed from the outer portion of the stipules. Forms showing the similar addition of a fourth pair of leaflets may easily be obtained, together with those which present the first and second pairs in relation with the stipules. In the leaf *a* there is an unpaired fourth leaflet on the right, but the stipule on the left is distinctly longer than its mate.

From the examination of mature rose leaves it appears, therefore, that leaflets are added from the stipules. It would be inferred that the basal leaflets are the last to develop, but that the stipules arise before the first pair of lateral leaflets. In the rose neither the terminal nor the basal leaflets show lobation or other evidence of leaflet production.

In the "high-bush" blackberry, *Rubus sp.?*, there is a different process of leaflet formation as shown in Figure 2. *A* is a simple leaf with stipules. In *b*, *c*, and *d*, by the lobation of the basal portion of the leaf blade, the first pair of leaflets is produced. The stipules are not involved in their formation. In *e*, *f*, *g* and *h*, a second pair of leaflets appears by the lobation of the basal leaflets. Thus the mature blackberry leaves suggest that leaflets arise, not from the stipules, but from the basal leaflets.

The sumac, *Rhus copallina* L., presents a third type as seen in Figure 3. The leaf *a* has five pairs of leaflets together with an undivided terminal leaflet; *b*, *c*, and *d* also have five pairs, but the terminal leaflet is lobed or divided and suggests the origin of the sixth pair of leaflets shown in *e*. In the sumac the addition of new leaflets is from the terminal leaflet, and never from the basal as in the blackberry. There are no stipules.

Leaves of the sumac type are generally called *basifugal* (Goebel

FIG. 1.— Leaves of the wild rose, *Rosa lucida*, Ehrh. ½ natural size.

prefers akropetal). Nägeli who believed that all leaves grew near their apices, studied particularly the leaf development in *Aralia spinosa* L. which is of the basifugal type.[1] At the distal ends of its chief subdivisions there are lobed leaflets like those of the sumac. Steinheil[2] who believed that leaf-growth was generally basal, considered that compound leaves were an exception in that their outermost leaflets were the youngest. Trécul[3] recognized both the basifugal type of compound leaf and the *basipetal* which would include both the blackberry and rose. He distinguished also a *mixed* and a *parallel* type. These are discussed and rearranged by Eichler[4] (pp. 16–21). In addition to basifugal and basipetal he recognizes six types, namely divergent, convergent, simultaneous, ternary, cyclical, and parallel (but the last is not in Trécul's sense). In the divergent form, the leaflets develop from the center toward both ends of the leaf; in convergent leaves they develop from both ends toward the center; and in the simultaneous type all the leaflets arise at one time. When a single leaflet divides to make three, the distinction between basifugal and basipetal can scarcely be made since the next pair of leaflets may arise from the terminal leaflet as in the sumac, or from the basal leaflets as in the blackberry; but these ternary leaves are usually counted as basipetal. Cyclical leaves may be either basipetal or basifugal; the two lateral basal portions of the blade become connected around the petiole in peltate form, as in Ricinus, Lupinus and others. In the parallel type, on both sides of the median line vertical divisions arise, parallel with the periphery of the leaf. This occurs in Foeniculum and others. In the parallel form the divisions may be basipetal or basifugal. Eichler states (p. 18) that "Other developmental types have never been observed either by me or by earlier investigators; but considering the manifold forms of leaf development doubtless other types exist."

[1] Nägeli, C. Wachsthumsgeschichte des Blattes von Aralia spinosa Lin. *Pflanzenphysiologische Untersuchungen*, Heft 1, Zürich, 1855.

[2] Steinheil, Ad. Observations sur le mode d'accroissement des feuilles. *Ann. des Sci. Nat., Partie Bot.*, 1837, ser. 2, vol. 8, pp. 257–307.

[3] Trécul, A. Mémoire sur la formation des feuilles. *Ann. des Sci. Nat., Partie Bot.*, 1853, ser. 3, vol. 20, pp. 235–314.

[4] Eichler, A. W. Zur Entwickelungsgeschichte des Blattes. Marburg, 1861, 60 pp.

In Eichler's tables *Rhus typhina* is with the basifugal leaves; "*Rosa canina, tomentosa, arvensis*, etc." are with the basipetal.

FIG. 2.— Leaves of the high bush blackberry, *Rubus sp.?* ½ natural size.

Rubus is not included, but the similar Potentilla is classed with the rose. Goebel[1] likewise places "all digitate leaves" with the

[1] Goebel, K. Organographie der Pflanzen. Part 2, Heft 2, Jena, 1900.

rose and calls them basipetal (p. 525). There are two serious objections to grouping the rose leaf with that of the blackberry or potentilla. Neither the terminal nor the basal leaflets of the rose are ever lobed to produce new leaflets as in the blackberry; and in the blackberry the stipules are not involved in leaflet production as in the rose. If the term basipetal is to be retained for the blackberry and potentilla type, the leaf formation in the rose may be described as *stipular*.

Embryonic Leaves.— The interpretation of series of leaves such as those shown in Figures 1–3 depends upon the study of their embryonic development, for they are mature leaves and can never add to their lobes or leaflets. The number of these parts is determined before the leaf expands.

According to Eichler (*loc. cit.*) a leaf may begin in two ways. In some cases, immediately below the tip of the axis, there arises simultaneously in all its parts, a wall-like proliferation of cambial tissue corresponding to the entire insertion of the future leaf together with its stipules, if it is to have any. In other cases, beneath the growing tip of the axis a low papilla or conical proliferation appears, which quickly spreads laterally so that more and more of the circumference of the stem is involved in the leaf formation. This spreading ends before the leaf begins to be subdivided into lobes. In one of these two ways the *primordial leaf* is formed, from which (and never from the stem) all parts of the mature leaf develop. They are not pushed out from the stem. The primordial leaf forms from the stem; after that, all growth of the leaf is only an elaboration of the primordial leaf.

After its formation, the primordial leaf begins to differentiate a stationary basal zone, which is concerned only with the formation of stipules, and a vegetative outer zone which produces the petiole and blade. Petiole formation always follows blade formation; the expansion is at least indicated before the stalk begins. In palmate and pinnate leaves all of the main subdivisions are generally mapped out before the appearance of the petiole. The mid-rib may be present before the blade expands, as is true especially of simple, feather-veined leaves and some compound, pinnate forms; or the expansion of the blade is primary and the formation of the chief veins secondary, as in many three-parted, pinnate, and palmate leaves.

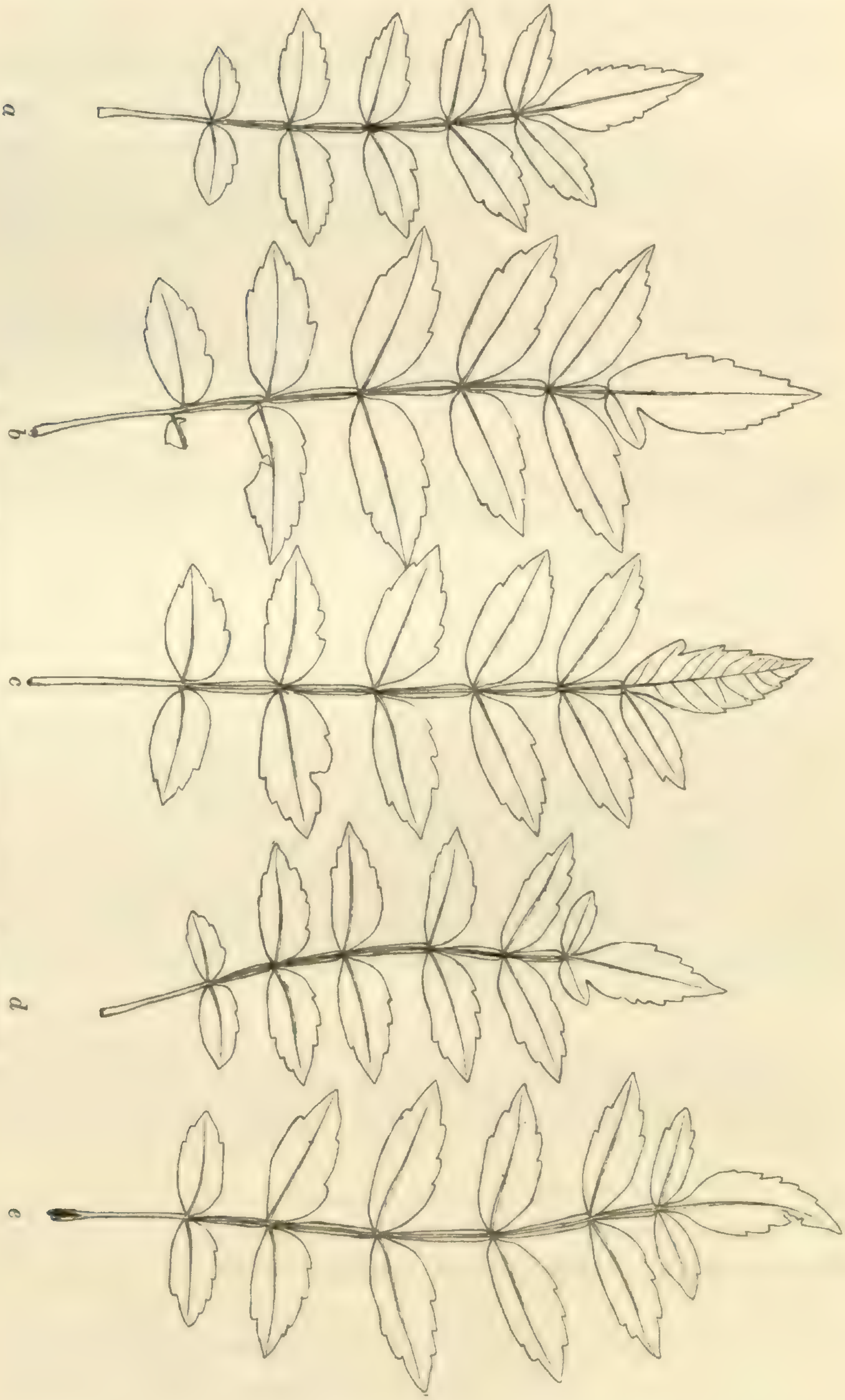


FIG. 3.— Leaves of the dwarf sumac, *Rhus copallina* L. ½ natural size.

The development of a leaf to this point is characterized by segmentation of its parts, accompanied by relatively little increase in volume. This is its *embryonic stage*. It is followed by the *stage of expansion* in which there is a great increase in volume without the addition of lobes or leaflets. The recognition of these two fundamental stages in leaf development is essential in interpreting mature leaves.

The embryonic development of the rose leaf is shown in Figure 4 *a*, *b*, and *c*. *A* is from Sir John Lubbock's drawing of the growing point, with side views of two primordial leaves in successive stages of development. He states[1] that the leaf "commences as a small knob at the side of, and immediately below the growing-point. When this knob has reached a certain length it presents two lobes (as on the left of the drawing). . . . . The lower lobe is one of the stipules, which according to Schacht appear first . . . . The stipule appears almost simultaneously with the first and upper leaflet, before any of the lower and later ones. These originate close above the stipules." On the right of Figure 4 *a*, the leaf presents lower lobes for the stipules, middle lobes for a pair of leaflets, and an upper lobe for the terminal leaflet. If by an arrest of development the stage of expansion should begin at this time, we should expect such a mature leaf as in Fig. 4 *d*. Expansion at the younger stage shown in *a* would produce a leaf like *e*; and at a still earlier stage, when the primordial leaf was but slightly indented, the stipules and blade would be scarcely separable, as in *f*.

Later stages in the embryonic development of the rose leaf are presented in *b* and *c*, after Trécul. They show the addition of the second and third pairs of leaflets respectively. It may be noted that in Eichler's opinion Trécul was misled by the early large size of the stipules into believing that they formed before the leaflets. Eichler finds that in various types of leaves the stipules may arise either as the first or the last of the primary divisions of the leaf blade, or at some intermediate time. In the rose they form last (*loc. cit.* pp. 26–27). If this were true, however, one might expect to find certain mature leaves without stipules, but such do not occur. The fact that if a mature leaf shows only

[1] Lubbock, J. On Buds and Stipules. London, 1899. 233 pp.

two divisions they will be terminal leaflet and stipules is in harmony with the early origin of the stipules as stated by Trécul and Lubbock.

The embryology of a basifugal leaf is shown in Fig. 4 *g*. Since drawings of the sumac are not available, Trécul's figure of *Gleditschia ferox* has been substituted. The youngest leaf, *l'*, is without lobes; in the older leaf, *l''*, the stipules (*s*) have appeared; and in the oldest leaf a succession of leaflets is forming from the base

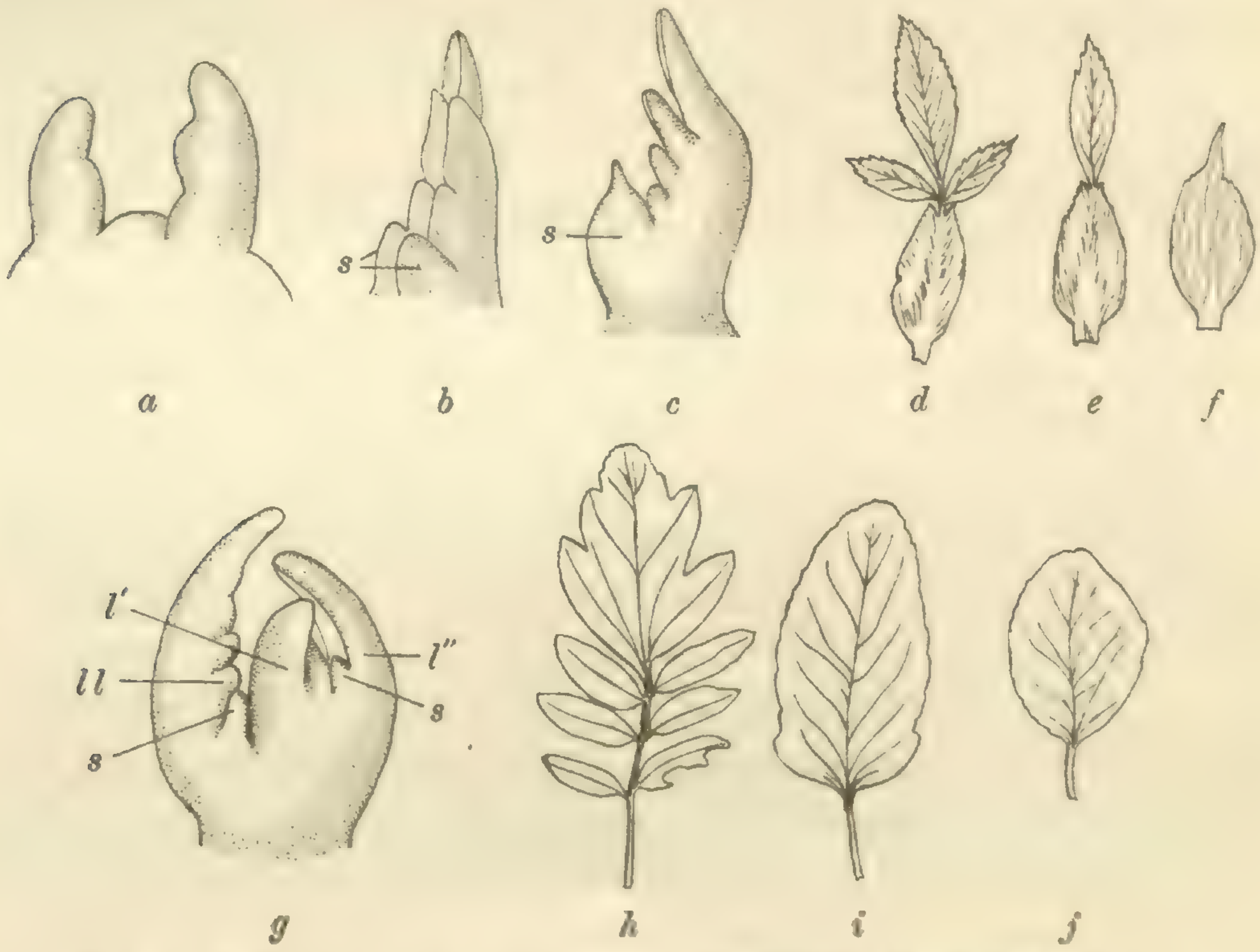


FIG. 4.— Embryonic leaves, and mature leaves showing an arrest of embryonic development. *a*, *b*, and *c*, embryonic rose leaves, *a* after Lubbock, *b* and *c* after Trécul. *d*, *e*, and *f*, mature rose leaves. *g*, embryonic leaves of *Gleditschia ferox*, after Trécul. *h*, *i*, and *j*, mature leaves of *Gleditschia triacanthos*. The embryonic leaves are considerably magnified; the mature leaves are reduced.

toward the apex (the lowest leaflet is marked *ll*). An arrest of development at this stage may produce such a leaf as *h*. The forms *i* and *j* may be compared with *l''*. In mature leaves of *Gleditschia triacanthos* the stipules, if retained, are very small and they do not appear in those figured.

From the consideration of the embryology of rose and honey locust leaves it appears that the developmental history may be

approximately inferred from the variations in mature leaves. The study of the mature leaves is therefore significant, but it ought to be confirmed by embryological examinations.

Evolutionary Significance.— A knowledge of leaf development is of great importance to the paleontologist, and in a paper entitled "Localized Stages in Development in Plants and Animals" Jackson presents a study of mature leaves from a geological and evolutionary point of view.[1] His conclusions are stated to be in the direct line and the natural outcome of Hyatt's principles of development. Professor Jackson's work upon leaves was continued by Cushman who published three papers on localized stages in this journal.[2] The leaves at either end of a branch which terminates in a flower are well known to be simpler than those along its middle portion. Simple leaves are expected near the bud scales, the sepals, and the cotyledons. St. Hilaire (quoted by Trécul) sought to explain this arrangement by nutritive conditions; the simple leaves in the young plant or near the flower are due to weakness and exhaustion. In full vigor leaves tend to become compound, and there are some instances in which cultivation in rich soil has favored the production of compound leaves. This explanation is not satisfactory, however, and Jackson proposes another. The early leaves are said to represent the adult types of ancestral forms; and the successive leaves between the cotyledons and the most complex forms which the plant produces record the evolutionary history of the species. The simplification of leaves toward the flower is considered a senile repetition, in reverse order, of the developmental series. In localized parts of the adult, as at the base of vigorous shoots, stages of leaf development may be found similar to those of young plants; their equivalents are to be sought in the adults of ancestral groups.

The nature of ancestral forms is for the geologist to decide; it

[1] Jackson, R. T. Localized Stages in Development in Plants and Animals. *Mem. of the Boston Soc. of Nat. Hist.*, 1899, vol. 5, no. 4, pp. 89–153.

[2] Cushman, J. A. Studies of Localized Stages of Growth in Some Common New England Plants. *Amer. Nat.*, 1902, vol. 36, pp. 865–885.

Studies of Localized Stages in Some Plants of the Botanic Gardens of Harvard University. *Amer. Nat.*, 1903, vol. 37, pp. 243–259.

Localized Stages in Common Roadside Plants. *Amer. Nat.*, 1904, vol. 38, pp. 819–832.

is generally assumed that their leaves were simpler in outline than those of existing species. If, however, it is true that the plant is recording its history in producing these simpler leaves, the reason why they occur in the places named remains as much a mystery as ever. The plant just before producing a flower can scarcely be regarded as weak, exhausted, or senile. The embryologist is content to find that the diverse forms of mature leaves arise from papillae which become characteristically lobed and molded before they expand. If expansion occurs before the modelling is complete, a simple form of leaf results. A more accurate account of the development of the papillae in various plants ought, however, to be obtained.

Summary.

Certain features of leaf development which were established some fifty years ago, should not be overlooked. These are primarily the basipetal and basifugal types of growth, which may be verified by collecting mature leaves, and which can profitably be taught to students of elementary botany.

Among the basipetal leaves of the earlier writers there are two radically different types, represented by the rose and blackberry respectively. The rose should be separated from this class and its leaf development may be described as *stipular*. Mature leaves indicate that the rose stipules are formed before the lateral leaflets, as observed by Trécul and Lubbock but denied by Eichler.

The formation of relatively simple leaves in plants which bear lobed or compound forms may be described embryologically, as an arrest of development in the primordial leaf followed by a stage of expansion, or by expansion before the embryological stage has been completed. Rapidity of growth may account for the constant location of the simpler leaves near the cotyledons, bud scales and sepals.

Cambridge, Mass.

CONTRIBUTIONS TO THE PLEISTOCENE FLORA OF CANADA

D. P. PENHALLOW

EARLY in the present year I received from Professor A. P. Coleman of Toronto University, a very fine collection of leaves from the Interglacial deposits of the Don Valley, Toronto. With them there was one small but rather well preserved fragment of a woody branch which it was possible to identify with accuracy. These specimens prove to be important since they serve to confirm in rather striking ways, conclusions already reached through previous studies of the Don material, and they furthermore afford additional evidence bearing upon the preglacial existence of types now unknown in the living state. It is therefore thought desirable to place on record such facts as are revealed by a study of this collection.

The last previous record of the Don plants was made by me in 1904 ('04) when thirteen species were passed in review. Since then both Berry ('06) and Hollick ('06) have added to our knowledge of the Pleistocene of Virginia and Maryland, and the evidence they bring forward goes to show that essentially the same flora characterized the entire region between Virginia and Ontario in Pleistocene time. The following species are included in the present studies:—

Acer pleistocenicum Penh.— This species appears for the fourth time in collections from the Don Valley, and in the present instance it forms a large percentage of the entire material. Most of the specimens are in fragments, but one or two are nearly perfect. One of the best of these is reproduced here on a diminished scale (Fig. 1), as it is more complete than that employed for the original description ('90, 327).

In the last enumeration of Canadian Pleistocene plants ('04, 72), attention was directed to the very close resemblance between *Acer pleistocenicum* Penh., and *A. lesquereuxii* Knowlton ('98) and the opinion was then expressed that the two are undoubtedly the

same. With the possibilities arising from more extended comparison of material representing a wider range of variations, the conviction becomes stronger that the opinion so stated is a tenable one.

Acer torontoniensis n. sp.— The Don collection embraces a number of specimens, some of them fairly perfect, representing a species of maple altogether unknown, either in the fossil or the living state. This leaf appears to present two principal variations which depend in part upon the relative depths of the principal sinuses and the character of the minor lobes or teeth, but chiefly upon the fact that in one form the base of the leaf is only slightly if at all lobed, while in the other case two large lobes extend downward from the insertion of the blade on the petiole and enclose the latter. Two principal veins extend from the base of the midrib to the corresponding principal lobes, and two subordinate veins of varying prominence extend diagonally downward from near the same point, into the two minor and variable lobes which form the base of the leaf blade. From this description, as also from the two specimens shown in Fig. 2 it will be seen that this leaf belongs to the same group with our common hard maples. Comparison with these latter also shows that its nearest representative among existing species is the common rock or sugar maple, *Acer saccharinum* Wang. Comparing the upper fossil of Fig. 2 with one of the more ordinary types of leaf of the sugar maple, it appears that the chief points of difference are to be found in the form of the sinuses and in the character of the large teeth or smaller lobes. If again we compare the lower fossil leaf in Fig. 2 with the corresponding type of leaf of the sugar maple, the resemblance becomes much stronger by reason of the similar basal lobes, which have unfortunately been much broken away in the fossil. The differences noted are such as might well result from changes incident to natural development, whereby the more simple tends in the direction of the more compound, and when to this there are joined the actual resemblances, they suggest a very intimate relation between the existing sugar maple and the fossil, of such a character as to indicate that the latter may be the ancestral form of the former.

A comparison of leaves of the sugar maple with those of the

Norway maple will show that although they differ materially with respect to venation, they resemble one another in a very remarkable manner as to the form of the sinuses and the detailed configuration of the lobes. These resemblances between two such well defined species, are precisely of the same order as those which are recognized in a comparison of the fossil with the sugar maple. It therefore becomes obvious that in the absence of flowers and fruit, it is not possible to effect a satisfactory specific differentiation

FIG. 1. *Acer pleistocenicum* Penh. × 0.55.

on the basis of leaf form only, but upon this basis the form now under discussion must be regarded as altogether different from any previously recognized fossil or recent species. The diagnosis of this leaf may be stated as follows:—

Leaves strongly and palmately veined; two principal veins arising at the base of the midrib and traversing the principal lobes; two inferior veins of varying prominence arising from near the same position but extending diagonally downward into the inferior lobes. Leaves three to five lobed; the two basal lobes variable,

sometimes small and inconspicuous, or prominent and extending downward so as to enclose the petiole as in Acer saccharinum Wang.; the sinuses broad and shallow; the terminal lobe with two large, lateral teeth; the lateral lobes with one or two large teeth on the lower side; the teeth acute, rarely somewhat acuminate toward the summit.

Hollick ('06, 234) has recently observed the occurrence of maple fruits in the Pleistocene of Maryland, but it is at present impossible to connect them definitely with any of the recognized leaves or wood so far studied.

Carya alba Nutt.— Although never abundant, the leaves of the hickory have been noted in three former collections from the Don. Their form and venation are so characteristic as to leave little room for doubt as to their true character.

Hollick ('06, 221, 222) now records the occurrence of three species, one from the Talbot and two from the Sunderland Formation of Maryland. Only one of these is specifically recognizable, and to this the name *Hicoria pseudo-glabra*, Hollick, is assigned.

Cercis canadensis L.— The red-bud, an altogether new constituent of the Don flora, is represented in the present collection by a few leaf fragments which are nevertheless sufficient to establish the identity of the species.

Cyperus sp.— Fragments of jointed stems showing a finely striated surface are referable to the genus Cyperus without specific differentiation. Such fragments are of common occurrence in material from the Pleistocene, and they possess little or no significance with respect to a knowledge of climatic conditions.

Gleditschia donensis n. sp.— One or two leaflets are clearly comparable with those of the genus Gleditschia to which they are referred under the name of *G. donensis*.

The genus is at present represented in North America by two species ('02, 76) of which the common three-thorned acacia, *G. triacanthos*, seems to be more nearly related to the fossil, and presents the closer resemblance with respect to geographical location.

Maclura aurantiaca Nutt.— One imperfect leaf is referable to the osage orange. Although not now growing in the same region,

this species has been recorded on previous occasions as occurring in the Don deposits of which it is a recognized feature.

Picea nigra Link.— This species is a constant constituent of the Don flora and has been recognized in nearly all previous collec-

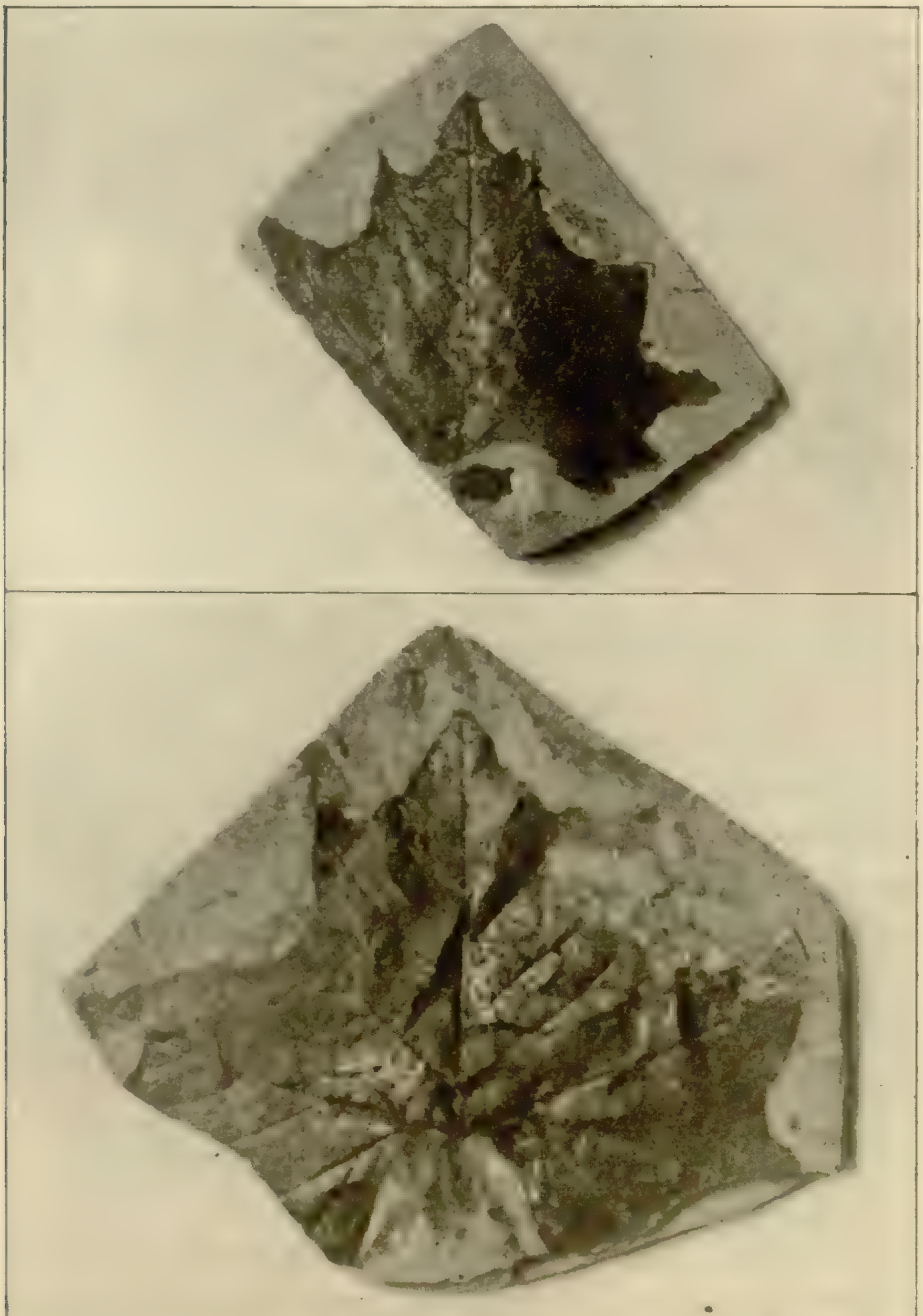


FIG. 2. *Acer torontoniensis* n. sp. × 0.55.

tions. As now, it is always represented by fragments of wood, usually small branches in a more or less altered condition.

Ostrya virginica Willd.— Although not recorded as embraced in

any previous collection from the Don, the leaves contained in the present one are sufficiently characteristic to make the determination reliable.

Platanus occidentalis L.— One small and imperfect leaf shows the characteristic venation of the sycamore. Although not often represented, this tree has nevertheless been found in a previous collection representing two localities, and it is a recognized constituent of the Don flora.

Hollick ('06, 231, 232) has shown the occurrence of *P. aceroides* Goepp., together with another large leaved but unnamed species, in the Sunderland Formation of Maryland.

Populus grandidentata Michx.— This well known but sparingly represented species is a well recognized element of the Don flora, and it once more appears in the present collection.

Prunus sp.— The genus is represented in the present instance by a single drupe of an oblong form. A similar but somewhat shorter fruit has been found on one previous occasion.

Quercus alba L.— The white oak is represented in the present collection by fragmented but well characterized leaves. This species has been observed previously in only one collection. The specimens obtained from Gaol Hill were so imperfect as to make the determination open to some question, but the present material is sufficiently perfect to remove all doubt.

Other oak leaves are also embraced in the 1906 collection, but the fragments are too incomplete to justify reference to a particular species. It is quite probable that they may represent the white oak, but this cannot be stated with any degree of certainty since the Don flora embraces no less than seven recognized species, any one of which they may be.

Under the name of *Quercus pseudo-alba*, Hollick ('06, 227) describes an oak from the Sunderland Formation of Maryland. The leaves which he figures bear a very close resemblance to those from the Don, and it is not unlikely that they may be the same, but a close comparison of more perfect specimens should be made before final decision is reached.

Robinia pseudacacia L.— A few leaflets of the common locust are found in the present collection. This species appears to be rather sparingly represented in the Don flora, since this is only the second time it has been found.

According to Hollick ('06, 234) this species occurs in the Talbot Formation of Maryland, and the leaflets figured by him are identical with those from the Don.

Tilia americana L.— The exceedingly well characterized leaves of the common linden or basswood, occur in the present collection in rather large numbers, some of them being fairly perfect. The species is sparingly represented in the Don Pleistocene, since it has been recognized in only one other collection.

A recent note by E. W. Berry, ('07, 80) directs attention to the occurrence of either *T. americana* or *T. heterophylla* in the Pleistocene clays at Fish House, New Jersey. The imperfect condition of the fossils makes it impossible to determine their correlation with one of the existing species, and in this emergency the specific name *T. dubium* originally assigned by Newberry to the leaves, is now retained but transferred from the genus Tilliaephyllum, and the citation therefore becomes *Tilia dubia* (Newb.) Berry.

Ulmus americana L.— The common American or white elm has been identified on former occasions as a prominent constituent of the Don flora, and it is once more represented in the present collection from the same locality.

Lesquereux ('83, pl. LIV, f. 10) has figured under the name of *U. pseudo-americana*, a specimen from the John Day Basin of Oregon (Upper Miocene) which very closely resembles the existing species and may well be regarded as its progenitor.

In a report upon Tertiary plants from the region of the International Boundary in British Columbia, collected by Prof. R. A. Daly in connection with the International Boundary Commission, and now in course of publication, certain elms are described on the basis of their wood structure, and it is seen that they differ but little from some existing species. Among them there is one which differs from the wood of the white elm to about the same extent that the leaf of *U. speciosa* Newb. differs from its more modern representative, *U. americana*. In a collection of woods from the Pleistocene of Elmira, N. Y., now being studied, either this or a closely related species is found, and the evidence therefore tends to show that Ulmus americana may be definitely traced back into Miocene time.

Ulmus pseudo-racemosa Hollick, has been found by Hollick in the Sunderland Formation of Maryland ('06, 228), and this

gives one more proof of the wide extension of the same flora, since the Elmira woods contain an elm which will be designated as *U. proto-racemosa*.

BIOLOGICAL CONSIDERATIONS

The present determinations lend emphasis to previous conclusions respecting the character of the Don flora, its relation to existing vegetation in the same region, and its indications of the existence of a climate warmer than at present and comparable with that of the middle and southern United States.

With four exceptions, Ostrya, Gleditschia, Cercis and *Acer torontoniensis*, the flora indicated by the present studies is identical with that previously determined to be characteristic of the Don Period or Warm Climate Period of the Pleistocene. But an examination of these four new elements, shows that they also, are quite consistent factors in the warm climate flora.

Gleditschia triacanthos L. which is undoubtedly the nearest living representative of the fossil, finds its northern limit of distribution according to Macoun ('83), in Ontario, and it occurs on the sand dunes of Pelee Point to which the seeds appear to have been carried across the Lake from Ohio. But according to Sargent ('02, III, 75) this species appears on the western slope of the Alleghany Mountains whence it extends westward as far as longitude 96°, and southward to Alabama, Mississippi and the Brazos River in Texas, from which it would appear that it is distinctly characteristic of a climate warmer than that now known in the region of Toronto, and comparable with that of the Don Period in Pleistocene time.

Cercis canadensis is practically unknown in Canada, although Britton ('97, II, 257) records it as occurring in southern Ontario. Sargent on the other hand ('02, III) gives its northern limit as New Jersey, whence it extends southward to Tampa Bay and westward to the Brazos River in Texas. The evidence which it affords of a warm climate is even more conclusive than in the previous case.

Ostrya virginica ranges from Cape Breton westward through the Valley of the St. Lawrence to Lake of the Woods and Rat Portage, northern Minnesota and the Black Hills of Dakota, and southward to northern Florida and eastern Texas. Although the tree is very common throughout all this region, Sargent ('02,

IX, 35) states that it is most abundant and of largest size in southern Arkansas and adjacent parts of Texas. It is therefore evident that in spite of its wide distribution and high northern range, it is essentially a southern type, and the evidence it affords is therefore in direct accord with that offered by those other representatives of the Don flora now recognized for the first time.

With respect to *Acer pleistocenicum*, very little of a definite character can be said since we know nothing of it except through its occurrence in the Don clays; but its very definite association with a warm climate flora leads to the conclusion that it also must bear the same relations to meteorological conditions, and that it must of necessity be a southern type.

Acer torontoniensis is similarly unknown beyond the Don clays, but the same evidence which applies to *A. pleistocenicum* must lead to similar conclusions with respect to its climatic relations. If this species is to be regarded as the actual progenitor of the sugar maple, it is perhaps somewhat difficult to explain satisfactorily how a southern type, or at least a type with a far southern extension, can have become so altered as to constitute an exclusively northern type, since the converse would be susceptible of a more ready explanation. If on the contrary, this be regarded as a distinct species with adaptation to a more southern climate, it becomes quite easy to understand how it was obliterated from the Toronto region by the southward movement of the ice sheet, in precisely the same manner that other species were driven out of the same area and ultimately confined to more southern localities.

The present studies serve to give renewed emphasis to the idea which has now passed beyond the limits of a working hypothesis, that successive northerly and southerly movements of the continental ice sheet, involving corresponding movements in vegetation, were productive not merely of plant migrations from north to south and *vice versa*, but that they established conditions which permanently eliminated those species which, we may suppose, occupied a somewhat unstable position in the flora and were therefore susceptible to a relatively slight change of surroundings. This conception is in exact accord with the present status of the genus Sequoia which, from a very wide distribution extending over the entire northern half of the continent as far as Alaska and Greenland, has become restricted to a very limited area on the

western slopes of the Sierra Nevada Mountains where, according to Gray ('89, II, 147) the two species now occupy an unstable position of such character that "a little further drying of the climate would precipitate their doom."

The evidence afforded by the Pleistocene clays of Toronto is therefore in accord, in this respect, with that furnished by certain Pleistocene deposits at Elmira, New York, and by the conclusions elsewhere stated with respect to the recession of Sequoia, Taxodium, and probably also Pseudotsuga, from the present Great Plains region of Saskatchewan and Alberta ('04, 64–65).

McGILL UNIVERSITY
MONTREAL

LITERATURE.

BERRY, EDWARD W.

'06. Pleistocene Plants from Virginia. Torreya, VI, 1906. pp. 88–90.

'07. A Tilia from the New Jersey Pleistocene. Torreya, VII, 1907. p. 80.

BRITTON, N. L. AND BROWN, A.

'97. Flora of the Northern States and Canada. II, 1897.

GRAY, ASA.

'89. Sequoia and Its History. Scientific Papers, II, 1889.

HOLLICK, ARTHUR.

'06. Systematic Palæontology of the Pleistocene Deposits of Maryland.
Cont. from the N. Y. Bot. Gard., No. 85, 1906. pp. 217–237, Pl. LXVII–LXXV.

KNOWLTON, F. H.

'98. Catalogue of the Cretaceous and Tertiary Plants of North America. U. S. Geol. Surv., Bull. 152, 1898.

LESQUEREUX, LEO.

'83. Cretaceous and Tertiary Flora of the United States. U. S. Geol. Surv. of the Terr. VIII, 1883. Pl. LIV, f. 10.

MACOUN, JOHN.

'83. Catalogue of Canadian Plants. Geol. Surv. Can., 1883.

PENHALLOW, D. P.

'90. The Pleistocene Flora of Canada. Bull. Geol. Soc. Amer., I, 1890. p. 327.

'04. Notes on Tertiary Plants. Trans. R. S. C., X, iv, 1904. pp. 57–76.

SARGENT, C. S.

'02. Silva of North America. III & IX. 1902.

THE SIGNIFICANT RESULTS OF A DECADE'S STUDY OF THE TUNICATA

WILLIAM E. RITTER

In any mass of detailed knowledge of organic phenomena, there is sure to be something of general significance for philosophical biology. Under the guidance of this principle I have tried to skim the cream from the results of the last ten years' researches on the Tunicata. These skimmings I present under the following captions:— 1, Taxonomy and Affinities; 2, Distribution; 3, Morphology; 4, Embryology; 5, Physiology.

1. **Taxonomy and Affinities.**— There are several questions of general interest that naturally arise under this head. The Tunicata being a comparatively small class of animals, does the progress made in getting hold of he new kinds indicate that we are approaching completeness in this direction? The class being as thoroughly pelagic at one extreme of its habitat, as thoroughly littoral at another, and as thoroughly abyssal at still another as any class of animals, what is being revealed as to the dependence of number of kinds upon environment? Is the progress of knowledge bringing out anything conclusive as to the greater success of certain types of organization over others because of better adaptation to environment?

Herdman's "Revised Classification of the Tunicata," published in 1891, contains a total of 538 species. This list supposedly includes all the species known at that time. By a reasonably careful enumeration, those described since that year number 521, making a total of 1069 species now known. The better explored portions of the sea, such as the Atlantic about the British Islands, the coasts of Continental Europe, and the Mediteranmean, have yielded very few of the new ones, probably not more than half a dozen. The regions that have contributed most are the Australian waters (Herdman and Sluiter); the seas traversed by the Siboga Expedition (Sluiter); the Ceylon region (Herdman); the southern South American region (Michelsen); the Japanese coasts (Oka and Hartmeyer); the Pacific North American region (Ritter);

the west African coast (Sluiter); the Arctic (Hartmeyer); the Antarctic (Sluiter and Herdman); the western tropical Atlantic (Sluiter and Van Name); and the western central Pacific (Sluiter).

As regards the sedentary Tunicata the general statement seems justifiable that *every portion of the sea at moderate depths, when first invaded by the collector, yields a considerable number of new species.* The further conclusion seems warranted that a few more decades of exploration, as active as the last three or four have been, would put us in sight of nearly the whole existing tunicate fauna so far as the open sea and shallower waters are concerned. Experience seems to indicate that here as perhaps in other branches of systematic natural history, after a particular locality has been explored with reasonable care, further collecting does not greatly alter the total number of recognized species. The new ones later brought to light are approximately offset by the elimination of spurious ones from the earlier lists. The slaughter of supposed species of Botryllus by Bancroft should be noted in this connection. Almost certainly the same sort of thing would happen in several other genera, were they to be studied with equal care. This suggestion relative to the rounding out of knowledge of the number of kinds of living tunicates does not touch the question of how in the future it may be found best to classify them.

As to the deployment of the species with respect to the extremes of habitat, of the 521 described since 1892 only about 40 are pelagic. Of these, 10 belong to the Thaliacea, 27 to the Larvacea, and the others to the Pyrosomæ. This is the result in spite of the fact that exploration has been prosecuted little if at all less vigorously in the pelagic than in the littoral realm. This is surely true as regards the Thaliacea and the Pyrosomæ. As to the Larvacea, the minuteness of the animals and difficulty of handling them results in their receiving somewhat less attention than the other groups. There can be no doubt that the living pelagic tunicates are much less abundant in kinds than the sedentary ones. Is this due to the fact that they are subject to less diversity of environment? This explanation is not of necessity the only one. It is possible that the small number of kinds is due to the fact that the group is waning or senescent. I am inclined to think a good case could be made for this hypothesis, at least as regards the Thalia-

cea. It is by no means impossible that could paleontology give its testimony on the history of this group, as it does for the Cephalopoda and the Foraminifera, for instance it might reveal a richness of ancestral kinds far greater than that presented by the modern fauna.

A matter of prime interest from its bearing on the problem of fitness to survive is the large number of kinds (species?) belonging to a few of the genera, or sets of illy separated genera, of sedentary ascidians. The most conspicuous groups from this standpoint are 1 Ascidia; 2, Molgula; 3, Cynthia with its close ally Rhabdocynthia; 4, Styela with the scarcely distinguishable Polycarpa; 5, Botryllus and its close congener Botrylloides; 6, Amaroucium with its near relative Aplidium; and 7, Leptoclinum. These seven groups contain more than 600 of the approximately 1000 species of simple and compound ascidians now described. There are recognized at least 80 genera in these two tunicate sections. In other words, as our scheme of classification now stands less than 14% of the genera contain fully 60% of all the species. It will be observed that these few prolific groups present all the leading types of sedentary ascidian organization. An analysis of the species in these groups with reference to the character of their environments would certainly not show that some of the types tend to be restricted to one set of external conditions while others are restricted to different conditions. *I do not believe there is anything in our present knowledge of ascidian structure, function, or distribution, to warrant the conclusion that the groups most abundant in kinds are so because of their greater fitness to survive, or their relative adaptability to external conditions.*

Little headway has been made toward determining the extrinsic affinities of tunicates. Indeed although nothing has turned up to shake confidence in their chordate nature, some of the newer results are puzzling rather than enlightening. Thus Goldschmidt reports the embryology of Appendicularia (strictly Oikopleura) to be so similar to that of the typical ascidian that little hope can be entertained of further light on the problem from this direction. He confirms the contention of Seeliger and others that there is no real metamerism in the tail of this animal. I have examined a number of stages in the larval life of a species of Oiko-

pleura and am able so far to testify to the correctness of Goldschmidt's observations. On the other hand Metcalf finds some evidence of metamerism in the rapheal nerve of the Molgulidæ. Perhaps these facts slightly support Perrier's view that the adult sedentary simple ascidian is nearest to the vertebrate ancestor and that consequently Appendicularia is a modified ascidian larva.

Seeliger and Metcalf doubt that there is a true homology between the tunicate and vertebrate hypophysis. Neither does Seeliger believe the vertebrate thyroid to be related genetically to the tunicate endostyle.

Largely from the character of the stigmata and the absence of an epicardium, Julin holds a Mediteranmean species called by him *Archiascidia* to be the most primitive ascidian.

As to intra-class kinships, perhaps nothing of greater general interest has come to light during the decade than that Octacnemus is an ascidian proper and has nothing to do with the Salpidæ. Metcalf and Ritter have made this positive.

The polyphyletic character of the compound ascidians is now admitted by probably all students of the class.

2. **Distribution.**— Some of the most interesting questions under this head are presented by the abyssal fauna. We now know at least 25 species that belong here and about half of these come from depths of 2000 fathoms, more or less. Some of the genera represented in this deep-sea fauna, though widely separated systematically, still present a common trait in the tendency to retrogression of the branchial apparatus. This is distinctly seen in genera so far asunder as Culeolus, Octacnemus, and Hypobythius. On the other hand species of familiar littoral genera are coming up from time to time from great depths, having no marks whatever that can be regarded as impressed upon them by their peculiar environment. For example I have now in manuscript the description of a Styela from 2200 fathoms off the California coast, which does not differ from several shore species more than these latter differ from one another; neither do its specific marks betray anything of the peculiarities of its habitat. No aspect of observational as contrasted with experimental natural history promises more light on the nature of species, so it seems to me, than do faunas of the profound ocean depths.

The cosmopolitanism of some of the pelagic species, notably *Salpa runcinata fusiformis*, is significant. It appears as if there is no part of any sea in which this animal does not flourish. Perhaps the data yet in hand do not warrant quite so sweeping a statement, but it is borne out by material now in my possession from many parts of the Pacific, and by already published data from other oceans. This Salpa is a close rival of some species of Sagitta and of *Eucalanus finmarkicus* in this regard.

We now have sufficient information about Arctic ascidians (Bonnevie, Kiear, Huitfeldt-Kas, Hartmeyer), and about those of the Antarctic (Herdman, Sluiter), to make it clear that this group lends little support to the "bipolar" theory of distribution. Fifteen years ago Herdman concluded that sedentary tunicates are more numerous in species, and are in general of larger size in higher latitudes than in the tropics and subtropics. In spite of some rather rich collections recently described from tropical waters, notably from Bermuda and the East Indies, it seems as though the generalization will stand. My own somewhat extensive experience with Pacific Ocean ascidian faunas appears to support it.

3. **Morphology**.— Knowledge of the adult anatomy of the group has been enriched in many directions. The structure of the appendicularian "haus" has revealed, particularly through the patient labors of Lohmann, an elaborateness that puts it along side the sting of the honey-bee as a puzzle to the student of adaptations. For one thing the apparatus turns out to be a strainer of the most exquisite fineness.

One of the most interesting results of Salensky's extensive studies on the anatomy of appendicularians is that the heart of these animals is far more simple than was supposed, and that it is probably homologous with the procardial organ of the ascidian proper.

Branching of the nuclei of some of the ectodermal secretory cells of Oikopleura occurs to such an extent that it may well attract the attention of those interested in general problems of cell structure and activity.

Metcalf's findings relative to the fusion or intergradation of nervous and glandular tissues in the neuro-glandular complex of several ascidians is noteworthy. Of general significance also may

be mentioned the tendency to multiplication of ganglionic outgrowths observed by Metcalf in Salpa.

4. **Embryology.**— Knowledge of tunicate development has progressed in numerous ways during the decade. According to my judgment two of these are particularly significant to the general biologist. They pertain to the very early embryonic life and to the multiplication of branchial stigmata. Among the investigations of the early embryo those by Conklin easily hold first place. To the embryologist, one set of facts brought out by Conklin stands with special prominence in the midst of many that are important. These relate to the question of organization in the unsegmented egg. Conklin's figures seem to furnish strong support for his statement that "it is doubtful whether any other case of cytoplasmic localization hitherto reported is more remarkable than that which has been described in the preceding pages for the ascidian egg."

Important as are these particular truths of ascidian development emphasized by Conklin's observations, there are other aspects of his work which appeal particularly to the general zoologist. In a résumé of what is known about cytoplasmic localization the author says:— "The annelids do not approach the chordates nor the echinoderms in the earliest stages of localization any more closely than in their cleavage stages or later development. *In short there is no convergence toward a common type of localization as one goes back to earlier and earlier stages in the ontogeny.*" In another connection Conklin points out that the pigmentation of the ovum which has served him so admirably in making out the "specification" in the development of Cynthia "may differ most remarkably in different genera of ascidians"; and that "the same may also be said of the yolk." Of the pigment he says, "this inert substance is not in itself of differential value, but it lies in a definite region of the egg and probably in a particular kind of protoplasm." The general zoologist, particularly the taxonomist, must inquire in the presence of these facts, Where is this sort of discovery going to lead us? If, viewing developing animals broadly, we find types of presegmental localization or in ordinary terms, types of *egg structure* that do not converge to a common type; and if eggs from genera so closely related as Cyn-

thia[1] and Molgula differ remarkably in "kinds of protoplasm," does it mean that by and by we are going to find specific characters in the eggs of aminals as well as in their adult condition? For my own part, speaking as a systematist, I am fully prepared to accept the full consequences of just this outcome. Furthermore I see something of the reach of such consequences.

The fact about the development of branchial stigmata which seems to me second in significance only to cytoplasmic localization, is that the origin of the epithelium of new stigmata is always dependent on that of preceding ones. The general question of how repetitive parts arise is basal. These results on the branchial stigmata of ascidians seem to be decisive so far. Selys-Longchamps, Dumas and Julin are specially to be mentioned in these investigations.

The somewhat bizarre notions which gained currency some time ago about the origin and fate of the follicle cells of the ascidian ovum seem to have been pretty nearly disposed of during the decade, thanks to Floderus, Bancroft, Todaro, and Korotneff.

Origin of the heart from the ectoderm is affirmed by Salensky. He treats this along with other instances of ontogenic origin of ascidian parts in defiance of rigid germ layer tenets, under the term "heteroblasty." This general subject, important as it is, has received no thorough investigation during the decade.

The regular succession of generations of ascidiozoids in the Botryllus colony observed by Pizon and Bancroft is a significant enlargement of our knowledge of development on the plane of organic animal societies.

5. **Physiology**.—Studies of the degeneration and rejuvenation of colonies of compound ascidians (Pizon, Caullery, Bancroft) have yielded significant results. For one thing the dying down of the colonies seems to be at least partly a normal senescent phenomenon and not due to the direct influence of environment.

Colonial as contrasted with zooidal individuality is suggested particularly by studies on growth and blood circulation in the Botryllus colony. The interesting fact is brought out by Ban-

[1] Attention should be called to the fact that if Conklin's eggs were from the *Halocynthia partita* of Verrill, he was really dealing with a Styela and not with the genus Cynthia at all.

croft that the ectodermal ampullæ in the test substance of the Botryllus colony are rhythmically contractile and have a regular circulatory office. There is coordinated activity among large numbers of ampullæ in the same colony and this seems to be without the intermediation of the nervous system.

The unique form of tunicate heart action has continued to attract attention. The most comprehensive study of it is by L. Schultze on Salpa. "The heart of Salpa is an example of purely muscular self-regulation in a highly coordinated mechanism of motion." This sentence summarizes Schultze's positive results. Neither cerebral influence nor blood pressure play a causal part in the phenomena. Of similar general import Bancroft and Esterly find proof of polarization through its own activity in the heart of Ciona. On the other hand Magnus, Hunter and Fröhlich bring forward rather strong evidence of the dependence of heart action in Ciona on ganglia and to some extent on the brain.

UNIVERSITY OF CALIFORNIA
BERKELEY, CAL.

NOTES AND LITERATURE

GENERAL BIOLOGY

The Agassiz Centennial.— On May twenty-seventh the one hundredth anniversary of the birth of Louis Agassiz was observed in Sanders Theatre, Cambridge, by a public reunion of his pupils. President Dana of the Cambridge Historical Society made the opening remarks and presented Colonel Thomas Wentworth Higginson, the chairman of the meeting. Letters were read from Professors Dall, Verrill, Wilder, Holland, Brooks, Ehlers and Bouvier. Professor A. L. Lowell spoke of the coming of Agassiz to America at the invitation of the Lowell Institute of Boston. Professors Niles and Gray told of his influence upon his pupils and over the community. Two poems, "The fiftieth birthday of Agassiz" by Longfellow, and "The prayer of Agassiz" by Whittier were read by Professor Winter. The meeting closed with the short address by President Eliot which is printed in full in this number of the *Naturalist.*

Commemorative meetings were held in other places. At Barnes Hall, Cornell University, Professor Burt G. Wilder delivered an address on "What we owe to Agassiz," a portion of which is printed in the *Cornell Era* (vol. 39, pp. 441–446).

To the younger generation of scientists the attractive and impressive personality of Agassiz belongs essentially with the past. Some children are still led by an inborn love of nature to hunt the fields and ponds for strange creatures, and to bring home small fishes to the watering trough. Sometimes they are later found at a school of medicine where parental warnings fail to keep their interests within the presumably lucrative bounds. Occasionally while quite young they are entrusted with important scientific work,— but they do not become naturalists.

It is said that Agassiz's first essay in natural history was a catalogue of the plants of the Jura Vaudois; later he was professor both of geology and zoology. "The plan of creation" was not too large a subject for a lecture course. The laboratory and the teacher's desk were attractive as a means to make known what was gathered from the sea or observed on the mountains. At the inauguration of Cornell University in 1868 Agassiz said,— "I am full of recollections of the Rocky Mountains. I wish this were a fitting time and place to speak of nature, its beauties

and its instruction, for I should know then that I was upon my own ground." Nature was studied in a large way, and directly, without the intervention of collectors and preparators. In this far-reaching knowledge and discerning love of nature, unlimited by class or kingdom, Agassiz was a naturalist. But the minute, laboratory method of study which he advocated has ended the succession. Given fishes to *study* and one is busy for life; the interest in glaciers, flowers, and the plan of creation are lost in the intensive activity of the ichthyologist. The love of nature may indeed remain, but the knowledge of nature must be narrow or superficial; and the scientist of to-day is far removed from the naturalist of the past.

To retain something of the broader interest has been the purpose of this journal. Through its pages many of Agassiz's pupils have circulated the teachings of natural history, and to spread such knowledge was their master's delight. The number for March 1898, contains seven articles commemorating the beginning of Agassiz's Harvard professorship which "marked a new era in the history of zoology in America." To these tributes it is a pleasure to add that of President Eliot.

The Preservation of Native Animals and Plants.— Both in America and in Europe the destructive effects of the growth of cities and spread of monotonously cultivated areas are receiving earnest attention. There is also widespread protest against every form of wilful and needless destruction of animals or plants. Those who feel some resentment that the portion of the world in which they live is not as attractive as their grandfathers found it, will find signs of better times in current literature and activities, a few of which will be cited. Beginning with the preservation of mammals we quote as follows from H. H. Johnston, in *Nature* (1907, vol. 76, p. 34).

"So far back as 1890 a movement began in Great Britain in favour of preserving wild life in lands under British control rather than allowing it to be exterminated by ruthless shooters. To some extent this movement was inspired from the United States. The creation of the National Park of the Yellowstone district, which was to lead to the formation of a 'paradise' for the nearly extinct bison, bears, prongbuck, deer, and wolves of central North America, suggested to several sportsmen-naturalists of Great Britain similar preserves in tropical lands, especially in Africa. Of course, long antecedent to that, British naturalists had at last induced the State to legislate for the preservation of the scanty remains of the British fauna, and although our measures

in this respect are still woefully inadequate, and a limited and old-fashioned class is allowed to push certain forms of sport at the expense of the wild fauna of these islands, still we have saved much; and in some districts of Great Britain birds and the smaller mammals really form constant and charming features in the landscape.

"The great invasion of Africa which began in earnest in 1890, directed public attention to the coincident slaughter of big game which everywhere accompanied the pioneering parties of the British. Just as Great Britain. . . .has gone far beyond any other nationality in the destruction of wild beasts and birds, her people are now foremost (though the United States is running almost neck and neck) in the world-movement for the preservation from extinction of all but the most harmful animals. We cannot be contented aesthetically with beef, mutton, poultry and pheasants, but to complete the interest of our lives we must have beautiful wild things around us to admire and study; there must be a place in our society for the rhinoceros, the lion, tiger, and even the wolf."

In southern New England only the weaker mammals remain. Attempts are made to introduce woodchucks, muskrats, and squirrels in the city parks where it is a crime to molest them, but in the country districts where these animals are much more attractive, bounties are offered for their destruction in case their skins are not sufficient lure. The wearing of furs is largely needless,— the lack of "buffalo robes" is not felt though the loss of the bison remains. A protest against the wearing of furs has recently appeared in *Life*.

The greatest interest in animal preservation attaches to the birds. Present legislation does not prevent the unnecessary decrease of many kinds. Brewster notes that "the Solitary Sandpiper is one of the few waders that have not diminished perceptibly in numbers within the past thirty years" (*The Birds of the Cambridge Region*, p. 165). There seems to be no good reason why the pleasure of a few in shooting shore birds should continue at the expense of many.

The scientific value of egg and skin collecting is relatively slight. *Bird Lore* and *The Condor* have recently been at odds whether oology is a science at all. It is clear that the deepest science is often the least destructive to nature. Embryologists have learned the development of birds by studying domesticated forms,— the chick more than all others together. The position of birds in the animal series is and will be based upon thorough anatomical and physiological study of these forms. Under the name of science, however, many a superficial collector has sought refuge.

In a neighboring town a beautiful museum has been erected, devoted exclusively to birds. It contains a specimen of the great auk. For scientific purposes, a synoptic collection of equal size, similar to that in Cambridge planned by Agassiz, would be of more value to the town. In the same village and quite as attractive, there is a long low barn with overhanging eaves under which there are some forty populous nests of the eave swallow. The owner has left out a few panes of glass from an upper window so that barn swallows are there also, and the two forms of birds can scarcely be confused after a visit to his place. The town ought to recognize its indebtedness to such a citizen as it does to the donor of a museum. How desirable he is as compared with the owner of the last large colony in the Cambridge region! Of that colony Brewster records that in 1869 "there were sixty or seventy occupied nests strung in a long row along the western side of a large barn. The owner of the place destroyed them all soon afterwards and they did not return. He objected to the presence of the swallows because their droppings disfigured his barn." Mr. Brewster's volume contains many such unpleasant memoranda. A great gray owl had the misfortune to visit Cambridge where it was observed by a woman who asked a certain Mr. Malone to shoot it. "It stared at him fixedly with its yellow eyes wide open, but showed no alarm at his presence although he went almost directly under the branch on which it was sitting. After watching it for a few moments, he fired at it but missed. At his second shot the bird flew across the paddock and alighted on the end of a spruce limb. It proved to be badly wounded and soon fluttered down to the ground where it stood on the defensive, presenting so menacing an appearance that he did not venture to touch it for several minutes. It died a few hours later."

A bill to protect these birds failed to be passed in Massachusetts but justice demands that they should be the property of all and not of the first selfish observer. All forms of native animals which are readily seen should be protected; if they are required in large numbers they should be reared for the purpose. The first remark of a systematist who was asked to identify a lot of turtles for dissection was,—"Some place is being depopulated of its tortoises!" Children should be taught to rear insects rather than to destroy all available Lepidoptera. In these days of inexpensive and quite accurate pictures, collections are not necessary for identification, and science is advanced by detailed studies of common forms,—the brown-tail caterpillar and the Colorado potato beetle — rather than by collecting luna and imperial moths.

Similar problems confront the botanist. Just as boys gather eggs and butterflies, girls make large bouquets of wild flowers and are often encouraged by the advice that 'the more they pick, the more there will be.' There is a mercenary motive also, for the arbutus, fringed gentian and sabbatia among others are tied in compact bunches and sold in the cities, — a practice which might properly be prevented by law. The mayflower is so protected in Connecticut. To prevent thoughtless and wilful destruction there are at least two important organizations, *The Wild Flower Preservation Society of America*, and the *Society for the Protection of Native Plants*. The officers of the latter are among the most eminent botanists of New England and its membership is about seventeen hundred. The *Naturalist* has received copies of its leaflets which are widely circulated without charge. They urge that the roots of plants shall not be disturbed, and protest particularly against the destruction of arbutus, gentians, Christmas evergreens, — mountain laurel and ground pine, various orchids, and all the rarer flowers, even by botanists. For decorative purposes daisies and buttercups may be gathered indiscriminately. Asters and goldenrod may be taken freely, except that flowers by the roadside should be left for general enjoyment. They quote Ruskin,— "Flowers seem intended for the solace of ordinary humanity; children love them; quiet contented ordinary people love them as they grow; luxurious and disorderly people rejoice in them gathered. . . ."

All of these efforts for the preservation of native plants and animals indicate the progress of natural science. They are based, not upon sentiment, but upon a more intelligent appreciation of nature; and they deserve success.

F. T. L.

ZOOLOGY

The Curious Mating Habit of the Fly *Rivellia boscii*.— The following observations were made near Toronto in the latter part of June. The flies were found in bright sunlight about noon on leaves of bushes and flowers in a garden border. The behavior of four pairs only will be described for though other pairs were seen going through similar movements, only four were watched from their first meeting until separation. In all cases the female runs about on the leaves in small circles and spirals varied by an occasional straight course. The wings are extended and moved slowly up and down; at intervals

she stops for a second or two and then goes on. The male who is much smaller follows closely and when the pace admits touches her abdomen with his proboscis or with one of his anterior pair of legs. Sooner or later he mounts the back of the female, the penis is extended and taps the abdomen of the female two or three times when the latter also becomes extended and copulation begins. This extension of the female's abdomen is necessary to connection and seems purely automatic, for it invariably occurs even when her previous and subsequent actions show that the male's attentions are not acceptable.

Pair I. In copula the wings keep in constant motion, while at intervals of three or four minutes a period of greater excitement arrives during which the wings of both are moved more rapidly and their probosces are alternately extended and retracted. After a few seconds of this excitement a droplet of colorless fluid appears at the end of the proboscis of the male and rapidly increases in size until from one-half to two-thirds of a millimeter in diameter. This is not a bubble but a solid globule. The male now raises his proboscis as high as possible and lurching forward with his body, brings it down with a sweep and transfers the globule to the proboscis of the female which she elevates to receive it. The movement is rapid and very deft. Under movements of the female's proboscis the globule now dwindles and disappears; evidently she eats it. This transference of a globule is repeated many times before the pair separate. The male maintains his position chiefly by grasping the abdomen of the female with the second pair of legs, the first pair resting either on abdomen or thorax.

Pair II. The male succeeded several times in mounting but each time was dislodged by the female by movements of her legs and whole body. Male number two appeared on the scene and mounting was allowed to remain. Male number one endeavored to displace him but failing several times, soon went off. After the first globule had been handed over by male number two he dismounted of his own accord and went off.

Pair III. After handing over the globule the male would dismount of his own choice and run in circles around the female who remained almost stationary. After three or four minutes he would mount, the globule would appear at once and be handed over as usual. This occurred many times in succession.

Pair IV. The globule would appear as usual but with less excitement on the part of the male, as shown by sluggish movements or none at all, of wings, legs, and proboscis. After appearing and increasing to the usual size it would decrease, evidently being consumed by

the male himself. This occurred five times in succession. At intervals the female struggled to rid herself of him but did not succeed. The sixth time that the globule appeared was immediately after one of these struggles; this time the globule was handed over but the male dismounted at once of his own accord and went off.

The habit itself is curious enough, but no less interesting are the variations noted and the decided imperfection of instinct in the male of pair number four. The apparent choice exerted by the female of pair number two, and the whole behavior of the pairs gave an impression that could not be harmonized with any theory of insect behavior that considered insects pure automata.

Another point of interest is the possible connection between these globules and those referred to by J. M. Aldrich and L. A. Turley in an article entitled "A balloon-making fly" (*Amer. Nat.*, 1899, vol. 33, pp. 809–812). The balloons are described as hollow, elliptical structures "composed entirely of a single layer of minute bubbles," and it is said that they are probably produced by the anal organs as in the leaf-hoppers "but no positive observations on this point could be made." The authors do not state plainly that the bubbles contain air; in the present case, however, there are certainly no bubbles, but solid droplets probably of salivary secretion.

The behavior of these flies suggests that of the pigeon as described by Dr. E. H. Harper (*Amer. Journ. of Anat.*, 1904, vol. 3, p. 354). He says,— "There is an act which regularly precedes copulation, in which there is an apparent regurgitation of some secretion by the male which is taken from his throat by the bill of the female, in somewhat the same manner as the young birds take their food. It is a less violent manifestation than the feeding of the young however. It is easy to see that here may be one of the sources of indirect stimulation to the female reproductive organs." (Compare with the stroking of the salamander recorded in the following note.)

Specimens of the fly were preserved and through the kindness of Dr. L. O. Howard, identified as *Rivellia boscii* (Desv.).

W. H. Piersol.

The Spermatophores of Salamandra.— In connection with Dr. Smith's account of the spermatophores of Amblystoma published in the last number of the *Naturalist*, the recent paper by W. Doeters van Leeuwen is of special interest (Über die Aufnahme der Spermatophoren bei *Salamandra maculosa* Laur., *Zool. Anz.*, 1907, vol. 31, pp. 649–653). The animals observed were in confinement but the

conditions were believed to be natural. At twilight the salamanders come out from the mossy logs, and the male having found a mate crawls under her body, working his way forward. His front legs are swung around those of the female and he strokes the under side of her head with his nose. After a time a spermatophore is deposited on the moss. It is a pyramidal structure 8–10 mm. high and 4–6 mm. wide, sharply pointed with the apex upward. After its deposition the male swings his body 90 degrees to one side, but retains his grasp, and his head remains beneath that of the female. The cloaca of the female is thus brought over the spermatophore which is taken up before the pair separates. Mating occurs from July to September or October, and the spermatophores are always deposited on land. The eggs are fertilized and in the following spring or early summer the young are laid. A new set of eggs is then mature and ready for fertilization.

F. T. L.

Stone-gathering Fishes. — In the *American Naturalist* for May (pages 323–327 of the current volume), Dr. Alfred W. G. Wilson has given important information and excellent illustrations of so-called "Chubs' Nests." Although, as stated in a foot-note, no account of these nests is included in my article on "Parental care among fresh water fishes," it is recorded (p. 436) that several American cyprinids "also take care of their eggs, especially the Horned Dace (*Semotilus atromaculatus*), the Black-headed Dace (*Pimephales promelas*), and the Stone-roller (*Campostoma anomalum*)." I did not give any further information for two reasons; the data in the books were unsatisfactory, and Professor Jacob Reighard had informed me that he would soon publish an account of the habits of these fishes.

The evidence as to the exact species that heaps the stones in question needs confirmation. Dr. C. C. Abbott, in "A naturalist's rambles about home" (1884, p. 408) positively declares that *Semotilus corporalis* (called by him *bullaris*) "differs materially from the birds and even many fish" in that "it does not concern itself with the care of its offspring. Once the eggs are laid upon their bed of sand, all care as to their future vanishes"; he says nothing about the oviposition of *Semotilus atromaculatus* noticed on page 409 and called by him *S. corporalis* (p. 479).

Semotilus atromaculatus occurs in Canada as well as *S. corporalis*; it is known not only as Dace but as Chub, both English terms being applied to this American fish which is no nearer one than the other.

The question thus arises whether the fish which prepared the chubs' nests observed by Dr. Wilson was *Semotilus corporalis*[1] or *S. atromaculatus*; the former has been declared not to be a nest-maker and the latter is known to be such.

Our own common catfish does indeed carry "stones *away* from its nest" but the following instance of the contrary habit has been described in my article (p. 453). The Australian catfish (*Arius australis*) according to Professor Richard Semon resorts to flat, sandy, and stony parts of the river under a rapidly passing current to spawn. "When depositing its eggs and building its nest the fish goes to work in the following way. It begins by preparing a bedding about half a yard in area, consisting of gravel and small pebbles among which it deposits the spawn which is instantly milted by the male. After this it covers the eggs by several layers of bigger stones, thereby preventing them from being washed away by the stream, or carried off by water birds . . . . or by marauding little fishes. The material for this defensive structure is derived from the above mentioned ring (surrounding the nest) which thereby becomes devoid of all stones and gleams brightly in its smooth garb of white sand. It is wonderful to observe the accuracy of the fish's handiwork and the perfect circle described by the ring. So far as I could see the fish moved the bigger stones by pushing them along with its tail. The whole affair shows a very clever arrangement, the eggs being well shielded from enemies, well ventilated by the current, and even protected against being mud-stifled (save in case of a downright flood)."

I may add that the earliest detailed notice of a stone-gathering cyprinid that I know of, was communicated by Dr. W. H. Gregg to the *American Naturalist* in 1879 (vol. 13, p. 321); the fish was identified by him as ***Rhinichthys atronasus***.

THEODORE GILL

[1] In Dr. Wilson's paper (p. 327) *Semnotilus corporalis* Mitchell should read *Semotilus corporalis* (Mitchill).

BOTANY

The Search for Mutations.— Few are inclined to doubt the reality of the mutations observed by DeVries in the cultivated evening primrose, but many have questioned whether these changes occur at all frequently in nature. The search for them has been active since the publication of *Die Mutationstheorie*.

Cockyane (*New Phyt.*, 6: 43–46, 1907) describes pink, rose pink, and even bright rose forms of *Leptospermum scoparium*. So far as he was able to determine these color varieties must have originated in single individuals by discontinuous variation.

Cockerell (*Bot. Gaz.*, 43: 283–284, 1907) reports that near Boulder, Colorado, *Euphorbia corollata* has only four glands instead of the five normal to the species. No plants with five were seen.

Rehder (*Bot. Gaz.*, 43: 281–282, 1907) records the discovery in British Columbia of a fine specimen of *Rhododendron albiflorum* with double flowers. There was petalody of the stamens and carpels, with a considerable increase in their number. Only a single, imperfectly developed anther was found. Wild rhododendrons with double flowers are rare; in the Alps *R. ferrugineum* with double flowers has been observed at least twice.

Focke (*Abh. naturw. Ver., Bremen*, 19: 74–75, 1907) announces the gradual change of *Datura tatula* to *D. stramonium*. The offspring of typical *D. tatula* became weaker and paler from year to year until finally vigorous *D. stramonium* plants were produced from the seed of the weaklings. Since the methods of culture and pollination are not given in detail these results cannot be accepted without verification. The author records also a number of variations which some might class as mutations.

In connection with the recent discussions of geographic isolation in the *American Naturalist*, the observations of Schaffner are of interest (*Ohio Naturalist*, 7: 41–44, 1906). He discovered a new variety of *Verbena stricta* growing in Clay County, Kansas, distributed over somewhat more than a square mile of territory and represented by thousands of specimens. The new form is characterized by a pinkish white corolla, and among many thousands of specimens no transitional forms were found. In some spots the new form was more abundant; in others the parent species predominated; and elsewhere the two

forms were about equally represented. Schaffner considered this unquestionably a mutation, and points to the significance of the fact that it has been able to persist and spread without any geographic isolation whatever.

The observations of Druery (*Journ. Roy. Hort. Soc.*, 31: 77–83, 1906) on the wild sports of British ferns are also pertinent. He records a case in which the cristate form of *Pteris aquilina* was found covering an area of several acres, having apparently superseded the normal form in this one locality. Druery has devoted much attention to the collection and cultivation of the wild sports of British ferns. The British Isles are particularly rich in these sports of extremely divergent character and often of great beauty. About 1200 wild forms have been catalogued as distinct although only some 40 species are listed for the flora, and the majority of these have sported only rarely. Most of the ornamental forms cultivated in gardens have originated in nature and not under the influence of cultural conditions. The spores collected from wild plants yield the anomaly in its full development, or in three generations at the most, so that there can be no suggestion of a gradual development by the selection of minute variations. In nature the aberrant and the typical forms are found growing together but no intermediates are to be seen.

Shull (*Science*, n. s. 25: 590–591, 1907) has been occupied for some time with pedigree experiments on the common shepherd's purse and now announces results of great interest based upon the examination of over 20,000 pedigreed individuals. Four elementary forms have been discovered which breed true when self fertilized or crossed within the limits of the same elementary species. Upon crossing, these forms hybridize in strictly Mendelian fashion. Other atypic forms which appeared in the cultures breed true to their characteristics and do not show Mendelian segregation, but Dr. Shull is unwilling to advance them as mutants since they were not produced from the seed of guarded flowers. Shull (*loc. cit.*) and Transeau (*Science*, n. s. 25: 269–270, 1907) both point out the significance of Mendelian hybridization in the persistence and migration of a newly arisen type. The recessive form is at no disadvantage from crossing with the parent in these cases but sometimes probably has the advantage.

Zoologists are more cautious than botanists in accepting the mutation theory. Whitman has recently criticized it (*Bull. Wisc. Nat. Hist. Soc.*, n. s. 5: 6–14, 1907). Duerden (*Rec. Albany Mus.*, 2: 65–96, 1907) in his studies of the genesis of color patterns in tortoises concludes that the color patterns must have arisen by gradual modification and not by sudden transformation. Ortmann (*Mem. of the*

Carnegie Mus., 2 :343–524, 1906) studied the crawfishes of Pennsylvania and states that "anything that looks like a 'mutation' in de Vries's sense is entirely unknown." Closely allied species either have distinct geographical distributions or if found in one locality they prefer different habitats.

W. D. Tower is of the opinion that "the evolution of the genus Leptinotarsa and of animals in general has been continuous and direct, developing new species in migrating races by direct response to the conditions of existence" (*Carnegie Inst.*, Publ. 48). He states that "there is not at present evidence to show the origin of any heritable variations in the soma"; and that "in these beetles we can get new permanent variations by stimulating the germ cells and in no other way." Such an inheritable character he produced artificially by subjecting adult beetles to abnormal conditions of temperature, moisture, and barometric pressure. The eggs produced and developing under these conditions give rise to new forms which breed true even under normal conditions. But the parent beetles when restored to normal conditions produce offspring of the original type. The new forms are therefore believed to be due to influences of environmental conditions on the germ plasm. F. E. Lutz of the Cold Spring Harbor Station has reviewed Dr. Tower's work from the mutationist's point of view, as follows (*Canadian Ent.*, 39: 176–179, 1907),—

"The author maintains that 'mutation is not a special kind of variability different from that of ordinary fluctuating variation, but it is a part of the normal variability, and the direct response of the germ plasm to stimuli.' He finds that 'extreme variates' are rare, occurring only once in 6,000 cases; and they *breed true*, a thing which ordinary variates do not do. This is my idea of a mutant.... The fact is, Tower has given us one of the strongest arguments for the importance of mutations that has ever been presented. He says,— 'The breeding 'mutants' in our gardens and laboratories cannot tell us how they would succeed in nature; my experience with these beetles is that they fare badly, and, as far as I can discover, that they play a minor role in the evolution of species.' However, he had already stated that not only did *pallida*, one of the 'mutants,' breed absolutely true for six generations in the laboratory with 'no tendency to revert to the parental species' (*decemlineata*), but that from 14 males and 15 females allowed to shift for themselves in nature, 1,580 *pallida* offspring of the 6th generation were found, and he 'felt that further experiment with this form unconfined in nature was neither safe nor desirable, and exterminated the entire lot.' It is true that 29 *pallida* are more than he ever found in nature at one time and place, but he did find 6 at Clifton,

Ohio, and he noted that occasionally, as at Cabin John Bridge, Md., in 1900, sports are relatively very abundant. . . . If I had been so fortunate as to obtain his results, I would have drawn quite the opposite conclusions, and would have supported the mutation theory most loyally. . . ."

Aigner-Abafi (*Ann. Hist.-Nat. Mus. Nat. Hung.*, 4: 484–531, 1906) describes aberrations or varieties of 113 forms of Lepidoptera, many of which are figured. He aims to include only such as may be of interest to the student of evolution, but offers no suggestions as to their phylogeny which, he believes, should follow experimental researches. He considers that a knowledge of these forms collected in nature will be of great interest in connection with their production by experimental means.

Melanism has received particular attention among mutationists. Porritt (*Rep. Brit. Ass.*, 76: 316–332, 1907) has given a detailed account of the increase of melanism in Yorkshire Lepidoptera. The author confines himself strictly to recording the facts, some of which seem to support the mutation theory although others do not.

In all these cases it is observed that zoologists are cautious about applying the term *mutant* to variations found in nature. Although the teratological studies so popular a few years ago have gained a new significance through the discoveries of De Vries, real progress lies only in the cultivation of these aberrant forms and the recording of their behavior in successive generations under guarded conditions.

J. A. Harris.

Biology in the Journal of Agricultural Science.— Although the real progress of science cannot be properly estimated by the counting of titles of journals, some notion of the interest which is being shown in scientific matters and of the degree to which specialization has extended may be had from this very source. The appearance of the new *Journal of Agricultural Science* indicates that another field of research has become enlarged, and that this division of applied science acquires a more direct means of spreading its benefits.

The purpose of the journal is to afford a "general channel for the publication and discussion of papers bearing on agriculture." Papers on zoology, botany, bacteriology, chemistry physics or geology are accepted if they have a bearing upon the definitely scientific problems of agriculture, but no papers dealing with matters of an ordinary commercial or farming character as distinct from agricultural science are to be admitted. The first six numbers of the journal, fine specimens of the product of the Cambridge press, are now at hand.

The name of W. Bateson on the editorial staff is an assurance that the pages will contain much of interest to students of Mendelism. As a matter of fact, of the forty-seven signed papers ten are devoted mainly to discussions of this new field of experimental work. Biffin has a paper on Mendel's laws of inheritance in wheat breeding, and a supplementary note on the same subject. He discusses also the hybridization of the barleys, the inheritance of sterility in the barleys, and the inheritance of disease resistance. Butler contributes a paper on the bearing of Mendelism on the susceptibility of wheat to rust. The problem of disease resistance is taken up from the histological side by Marryat. Under the title "Hybridization of Cereals," Wilson reports Mendelian studies of oats and barley. Ball presents a note on Mendelian heredity in cotton. Humphries and Biffin discuss the improvement of English wheat. It will be noted that the Mendelian investigations reported are almost exclusively on cereals,—the group of agricultural plants where the results may be expected to have the highest economic importance. An exception is a paper by Wood on the inheritance of horns and face color in sheep.

Other papers of interest to botanists are an article on the influence of pollination in the development of the hop, by Howard; papers on the chemical composition of the swede and mangels, and a paper discussing the law of sequence in the yield of wheat.

A journal of this type should contribute greatly to agricultural progress; moreover it promises to be a mine of facts for the student of pure science.

J. A. Harris.

Notes.—*A new flora of Louisiana.* Students interested in the flora of Louisiana must often have regretted the very incomplete publications upon this subject. The "Florula Ludoviciana" of Rafinesque, and the books of Darby and Chapman all fall far short of treating it satisfactorily.

It will be good news that the newly formed Museum Commission of the State of Louisiana, which is charged with the duty of creating a State Museum in New Orleans, contemplates publishing every six months a volume dealing with the history and resources of the state, and that the first volume will be a Flora of Louisiana by Prof. Reginald S. Cocks. This gentleman has given many years of study and active personal research to the work, which would have been published some years since but for an unfortunate fire which destroyed a part of his material.

William Beer.

PUBLICATIONS RECEIVED

From May 1 to June 1, regular exchanges not included
The year of publication, when not otherwise noted, is 1907

BURKETT, C. W., AND POE, C. H. *Cotton, Its Cultivation, Marketing, Manufacture, and the Problems of the Cotton World.* New York, Doubleday, Page & Company, 1906. 8vo, IX + 331 pp., illus. $2.00.— SCHWARZ, G. F. *The Longleaf Pine in Virgin Forest.* New York, John Wiley & Sons, 1907. 12mo, X + 135 pp., illus. $1.25.— SMITH, E. A. *The Underground Water Resources of Alabama.* Geological Survey of Alabama, Montgomery, The Brown Printing Company, 1907.

ALBERT I, PRINCE OF MONACO. Meteorological researches in the high atmosphere. *Scottish Geog. Mag.*, Mar., pp. 113–122, illus.— BERG, L. A review of the cobitoid fishes of the basin of the Amur. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 435–438. A review of the species of the tenspined sticklebacks or Pygosteus from East Asia. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 451–454.— CAUDELL, A. N. The Decticinae (a group of Orthoptera) of North America. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 285–410, 94 figs.— CIRERA, R. Notice sur l'observatoire et sur quelques observations de l'éclipse. *Mémoires de l'Observatoire de l'Ebre*, 1906, no. 1, pp. 1–56, pls. 1–12.— COBB, J. N. and KUTCHIN, H. M. Report on the fisheries of Alaska. Report on inspection of the salmon fisheries. *Bureau of Fisheries*, doc. 618, 70 pp.— EIGENMANN, C. H. The poeciliid fishes of Rio Grande do Sul and the La Plata basin. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 425–433, 11 figs.— FARRINGTON, O. C. Analyses of iron meteorites compiled and classified. *Field Columbian Mus.* geol. ser., vol. 3, pub. 5, pp. 59–110.— GRIFFITHS, D., and HARE, R. F. Prickly pear and other cacti as food for stock II. *N. Mex. Agric. Exp. Sta.*, 1906, bull. 60, 134 pp., 7 pls.— HAY, O. P. A new fossil stickleback fish from Nevada. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 271–273, 3 figs.— JUDAY, C. Notes on Lake Tahoe, its trout and trout-fishing. *Bull. of Bur. Fisheries*, vol. 25, pp. 133–146.— KELLOGG, R. S. The timber supply of the United States. *U. S. Dep't of Agric.*, forest service, circ. 97, 16 pp.— KOEHLER, R. Note préliminaire sur quelques Astéries et Ophiures provenant des campagnes de la Princesse-Alice. *Bull. de l'Inst. Océanogr. de Monaco*, no. 99, 47 pp. — LINTON, E. A cestode parasite in the flesh of the butterfish. *Bull. U. S. Bur. Fisheries*, vol. 26, 1906, pp. 111–132, pl. I and II.— LINTON, E. Notes on Calyptrobothrium, a cestode genus found in the torpedo. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 275–284, 8 figs.— LYON, M. W. Remarks on the giant squirrels of Sumatra, with descriptions of two new species. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 439–445, pl. 33.— MAILLARD, L. L'Industrie des Salines côtières. *Bull. de l'Inst. Océanogr. de Monaco*, no. 100, pp. 43, 13 pls.— NESOM, G. E. Bureau of agriculture districts of the Philippines. Control of rinderpest. Carolina golden rice. Notes. *Dept. of the Int., Bur. of Agric., P. I.*, Press bull. no. 9, 11 pp.— RICHARDSON, H. A new terrestrial Isopod from Guatemala, the type of a new genus. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 447–450, 1 fig.— SARS, G. O. Notes supplémentaires sur les Calanoïdés de la

Princesse-Alice. *Bull. de l'Inst. Océanogr. de Monaco*, no, 101, 27 pp.— SKIFF, F. J. V. Annual report of the director to the board of trustees for the year, 1906. *Field Mus. of Nat. Hist.*, report ser., vol. 3, no. 1, 108 pp., 17 pls. — SHIMEK, B. Botany in its relation to good citizenship. *Proc. Io. Acad. Sci.*, 1905, vol. 12, 6 pp., 4 pls.— SHIMEK, B. Flora of Winneshiek County. *Io. Geol. Sur.*, 1906, vol. 16, pp. 147–211.— WILSON, C. B. Additional notes on the development of the Argulidae, with description of a new species. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 411–424, pls. 29–32.

ATTI DEL CONGRESSO INTERNAZIONALE DI SCIENZE STORICHE, vol. 1.— BOLETÍN DE LA SOCIEDAD ARAGONESA DE CIENCIAS NATURALES, vol. 6, nos. 2, 3 and 4.— BULLETIN OF THE CHARLESTON MUSEUM, vol. 3, nos. 4 and 5.— IV CONGRESSO INTERNAZIONALE DEI MATEMATICI.— OKLAHOMA BOARD OF AGRICULTURE, bull. 8.— PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES FOR 1906, vol. 31, part 4.— SCHOOL REVIEW, vol. 14, no. 5.— THIRTY-FIFTH ANNUAL REPORT OF THE BOARD OF DIRECTORS OF THE ZOOLOGICAL SOCIETY OF PHILADELPHIA.— THIRTY-SEVENTH ANNUAL REPORT OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO.— UNIVERSITY OF COLORADO STUDIES, vol. 4, no. 3.

(No. 486 was issued June 22, 1907).

THE AMERICAN JOURNAL OF SCIENCE

Established by BENJAMIN SILLIMAN in 1818

The Leading Scientific Journal in the United States

Devoted to the Physical and Natural Sciences, with special reference to Physics and Chemistry on the one hand, and to Geology and Mineralogy on the other.

Editor: EDWARD S. DANA

Associate Editors: PROFESSOR GEORGE L. GOODALE, JOHN TROWBRIDGE, W. G. FARLOW, and WM. M. DAVIS, of Cambridge; PROFESSORS A. E. VERRILL, HENRY S. WILLIAMS, and L. V. PIRSSON, of New Haven; PROFESSOR G. F. BARKER, of Philadelphia; PROFESSOR JOSEPH S. AMES, of Baltimore; MR. J. S. DILLER, of Washington.

Two volumes annually, in **monthly numbers** of about 80 pages.

This Journal ended its *first* series of 50 volumes as a quarterly in 1845; its *second* series of 50 volumes as a two-monthly in 1870; its *third* series as a monthly ended December, 1895. A FOURTH SERIES commenced in January, 1896.

Subscription price $6.00 per year or 50 cents a number, postage prepaid in the United States; $6.40 to foreign subscribers of countries in the Postal Union. A few sets on sale of the *first*, *second*, and *third* series at reduced prices. *Ten-volume index numbers* on hand for the second and third series.

THE AMERICAN JOURNAL OF SCIENCE

NEW HAVEN, CONN.

FOR BIRD STUDENTS AND BIRD LOVERS EVERYWHERE.

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

EDITED BY J. GRINNELL.

OFFERS IN VOLUME 9

In MAKE-UP, the highest grade in paper, typography and illustration and every detail that counts.

In ILLUSTRATION, the best work of Messrs. Finley and Bohlman, work that is unsurpassed in any field.

In SUBJECT MATTER, the results of recent studies by active workers in the western field; interest and scientific value, the standard.

SUBSCRIPTION, $1.50 PER YEAR. SAMPLE COPY, 30 CENTS

H. T. CLIFTON, BUSINESS MANAGER, P. O. BOX 404, PASADENA, CAL.

For Summer Reading

What could be better than a Three-Months' Trial Subscription to

The Living Age?

One dollar will bring you this Magazine every week for three months

Containing

THE BEST FICTION
THE BEST ESSAYS
THE BEST LITERARY CRITICISM
THE BEST TRAVEL ARTICLES
THE ABLEST DISCUSSIONS OF PUBLIC AFFAIRS

With the whole range of contemporary English periodicals from the Quarterlies to Punch, to select from, THE LIVING AGE is able to give its readers every week a larger variety of material written by the most brilliant writers than any other single magazine.

THE LIVING AGE has been published every Saturday without missing an issue for more than 63 years and was never more indispensable than now to intelligent readers.

TERMS: SIX DOLLARS A YEAR
Three-Months' Trial Subscription one dollar

The Living Age Company

6 BEACON STREET, BOSTON

VOL. XLI, NO. 488 AUGUST, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

Page

I. Observations on the Natural History of Diving Beetles
JAMES G. NEEDHAM AND HELEN V. WILLIAMSON 477

II. Habits of the Short-tailed Shrew, *Blarina brevicauda* (Say)
A. FRANKLIN SHULL 495

III. Notes and Literature: *General Biology;* The philosophical problem of life.— The capitalization of specific names. *Anthropology;* Handbook of American Indians north of Mexico.— Games of the North American Indians. *Zoology;* Oogenesis in insects.— Parthenogenesis of *Bacillus rossii.*— Phagocytosis.— Histolysis in queen ants.— Notes on entomological literature. *Botany;* The fungi of termite nests.— The longleaf pine.— Purple-producing bacteria. *Geology;* Rate of recession of Niagara Falls 523

IV. Publications Received 543

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALES HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.Sc., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology, Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *August, 1907* No. 488

OBSERVATIONS ON THE NATURAL HISTORY OF DIVING BEETLES

JAMES G. NEEDHAM AND HELEN V. WILLIAMSON

OUR predacious diving beetles of the family Dytiscidæ are fairly well known as museum species, but the study of their life histories and habits has been singularly neglected. A number of our genera and a few of our species occur also in Europe, and the natural history of some of these has been studied there; but practically nothing has been done in this line in our own country. Therefore the following observations on the habits and adaptations of the group may serve to direct attention to an unworked but interesting field.

Dytiscidæ are very common at Lake Forest, and are very accessible in a campus pond that lies almost under the windows of the biological laboratory. They illustrate very well the more obvious phenomena of adaptation, and have been much used by the senior author for that purpose with classes for a number of years. The material incidentally accumulated in that work, combined with special studies of life histories and habits made by the junior author during the academic year 1905–6, will constitute this paper.

The campus pond (locally known as the "Gym Pond") from which our material has mainly been obtained, is an artificial one, made by damming a short, spring-fed branch of one of the ravines that bound the campus. It has been in existence for many years, and conditions in it are now quite natural. It is some sixty meters long and about half as wide, and it attains a depth of four and a half meters in its deepest part, near the dam. Toward the other end it becomes shallow, and is filled with a dense and clear growth

of cat-tails (Typha). There is very little other vegetation in it anywhere, but the hollows of its shores become filled in autumn with oak leaves from the surrounding forest trees.

It is in the typha beds of the upper end of the pond, extending from the shore outward into water of about a meter in depth, that the diving beetles are commonly found. These beds cover an area of but little more than a square decameter, but in them we have found twenty-nine species of Dytiscidæ, as follows,—

Laccophilus maculosus Germar
Laccophilus fasciatus Aubé
Laccophilus proximus Say
Hydrovatus cuspidatus Germar
Bidessus lacustris Say
Bidessus flavicollis Lec.
Bidessus affinis Say
Cœlambus inequalis Fabr.
Cœlambus punctatus Say
Cœlambus dispar
Cœlambus acaroides Lec.
Cœlambus nubilus Lec.
Cœlambus impresso-punctatus Sch.
Deronectes catascopium Say
Hydroporus undulatus Say
Hydroporus modestus Aubé
Hydroporus dichrous Melsh.
Ilybius confusus Aubé
Coptotomus interrogatus Say
Agabus subfuscatus Sharp
Agabus disintegratus Cr.
Rhantus notatus Fabr.
Colymbetes sculptilis Harr.
Hydaticus piceus Lec.
Acilius semisulcatus Aubé
Acilius fraternus Harr.
Dytiscus hybridus Aubé
Thermonectes basilaris Harr.
Graphoderes cinereus Linn.

No other Dytiscidæ have been found at Lake Forest, except two that are occasionally cast up on the beach of Lake Michigan and that we have picked up from the drift line,— *Agabus semipunctatus* Kirby and *Cybister fimbriolatus* Say.

Distribution by Size and Depth of Water.— The seven species of the above list that are marked with a * are very common and easily obtained; and being fairly representative of the family, these were made the basis for the observations which follow. These fairly represent the striking difference in size that is found in this family coupled with an almost unparalleled uniformity of shape (Fig. 1.)

The shoreward distribution of these beetles corresponds roughly with their size: the largest are found in the deepest water, the smallest nearest shore. Dytiscus is usually found in the more open places between the outposts of the typha beds in the deepest

water, and Acilius is adjacent to it on the shoreward side, although both (as well as the following species) may range shoreward foraging. Coptotomus abounds in water about a third of a meter in depth, and loves to disport itself in the narrow aisles between the typha clumps. Laccophilus dwells amid the fallen stems and trashy accumulations nearer shore, and is less in evidence in open water. Hydroporus and Cœlambus love the shoals into which one can look down while sitting on the bank, while Bidessus clings to the very shore line: it has nearly always been found by us within a few inches of dry land.

The larvæ of these forms show, likewise, a general distribution in depth corresponding to their size although the larvæ keep more

Fig. 1.— Silhouette print of seven adult diving beetles, illustrating the uniformity of shape and disparity of size found in the family Dytiscidæ: natural size. 1, *Dytiscus hybridus* Aubé. 2, *Acilius semisulcatus* Aubé. 3, *Coptotomus interrogatus* Fabr. 4, *Laccophilus maculosus* Germ. 5, *Hydroporus undulatus* Say. 6, *Cœlambus inequalis* Fabr. 7, *Bidessus lacustris* Say.

closely to cover of vegetation than do the adults. Dytiscus larvæ are found chiefly in the more open vegetation in the deeper water: Bidessus larvæ, at the shore line: and the others ranged between. It must not be understood that there is any such definite and sharply limited zonal distribution as aquatic plants on such a sloping shore often exhibit: that is not to be expected in animals possessed of such excellent powers of locomotion: we have meant to indicate merely the favorite haunts of each species, and the general correspondence between size of beetle and depth of water.

The accompanying table gives a more precise statement of the difference in size of the seven common forms of adult beetles already mentioned. The length was measured with a metric

caliper rule. Weight was determined with a chemical balance. Live beetles were weighed inclosed in envelopes of absorbent paper to remove the excess of moisture; then the weight of the paper with its contained water was deducted, and the remainder was divided by the number of the beetles used. By this means fairly accurate average weights were secured. In the other columns of the table are expressed with much less accuracy the comparative excellence of these seven beetles with respect to their different modes of locomotion.

Name	Length	Weight	Order of excellence in Swimming	Walking	Jumping
Dytiscus hybridus	27.6 mm.	1.303 grams	1	7	5
Acilius semisulcatus	14.1	.1936	2	6	2
Coptotomus interrogatus	7.9	.033	3	5	3
Laccophilus maculosus	5.5	.0142	4	4	1
Hydroporus undulatus	4.0	.010	5	3	4
Coelambus nubilus	2.9	.0032	6	2	6
Bidessus lacustris	2.0	.0005	7	1	*

The Activities of the Adult Beetles. — There is a very marked difference in the swimming powers of these beetles. Such forms as Cybister probably manifest the highest efficiency in the family. The long beautifully fringed hind legs are moved synchronously; the flattened and fringed tarsi and the blade-like lower tibial spur meet the water squarely, and each stroke sends the body forward several times its own length; whereas the rapid strokes of the scantily fringed feet of some of the lower members of the family, little modified in their motion from that employed in walking, produce individually but little result in forward progress. In arriving at an estimate of the swimming capacity of the seven forms listed in the above table the actual distance traversed per second was determined, and also the distance for each stroke of the swimming legs. In order to make just allowance for differences of size, this distance was expressed in terms of length of body. There was some difficulty in making these measurements, owing to the extreme rapidity of movement of the legs in the case of some of the smaller beetles, and owing also to the irregularity of their movements. In general, the ability to hold a straight course, to control equilibrium in turning, and to economize effort by elimina-

* Could not be induced to jump at all.

tion of useless motions of the fore legs was also taken into account and the estimated average is expressed in the table. Beetles fresh from the pond were used in every case.

Walking was compared by turning the beetles out upon a long sheet of blotting paper before a window, and allowing them to run toward the light. Excellence at walking was estimated not so much by speed as by ability to support and propel the body upon all of the feet. The greatest speed across the paper was occasionally attained by Dytiscus but it was not walking: it slid along on its belly, with its hind feet high in air, its front feet reaching forward, catching the hooked claws and drawing the body after. Bidessus, however, gets up on its feet and runs like a ground beetle, freely using all its tarsi. There is in Bidessus none of that flopping and floundering that characterizes the progression of the more specialized forms when out of water.

Jumping, in this table, covers any sort of sudden springing forward in air. The hind feet alone may be used very effectively, as in Laccophilus which is by far the best jumper of the lot, but they may also be assisted by the wings. It is not an uncommon thing to see at the pond a Laccophilus suddenly emerge from some trash floating on the surface and instantly spring into the air, using its wings as well as its legs, and then drop on the water and disappear instantly beneath it: for Laccophilus can take flight very quickly. The slow and lumbering start of most members of the family, is not at all characteristic of this beetle. The superior jumping powers of Laccophilus are explained in large part by the structure of its legs; especially their equipment of tarsal spines (Fig. 2 *A*).

The order of excellence in swimming and walking in this series of beetles has been determined by classes of students at Lake Forest for a number of years, and it has always been found as it stands in our table. The suspicious regularity of the figures raised some doubts in our minds as to their correctness: so the junior author went over the work of determining them carefully anew, with the result that they appear to be entirely confirmed. Doubtless such close correlation between size and excellence of swimming would not hold everywhere among the Dytiscidæ. Some of the smaller, more convex forms are very highly specialized. Our

series of seven selected at first solely on account of availability and abundance happened to be a most excellent one for illustrating the law of specialization. Nothing could be clearer than that, in this series, increasing fitness for locomotion in water accompanies increasing unfitness for locomotion on land.

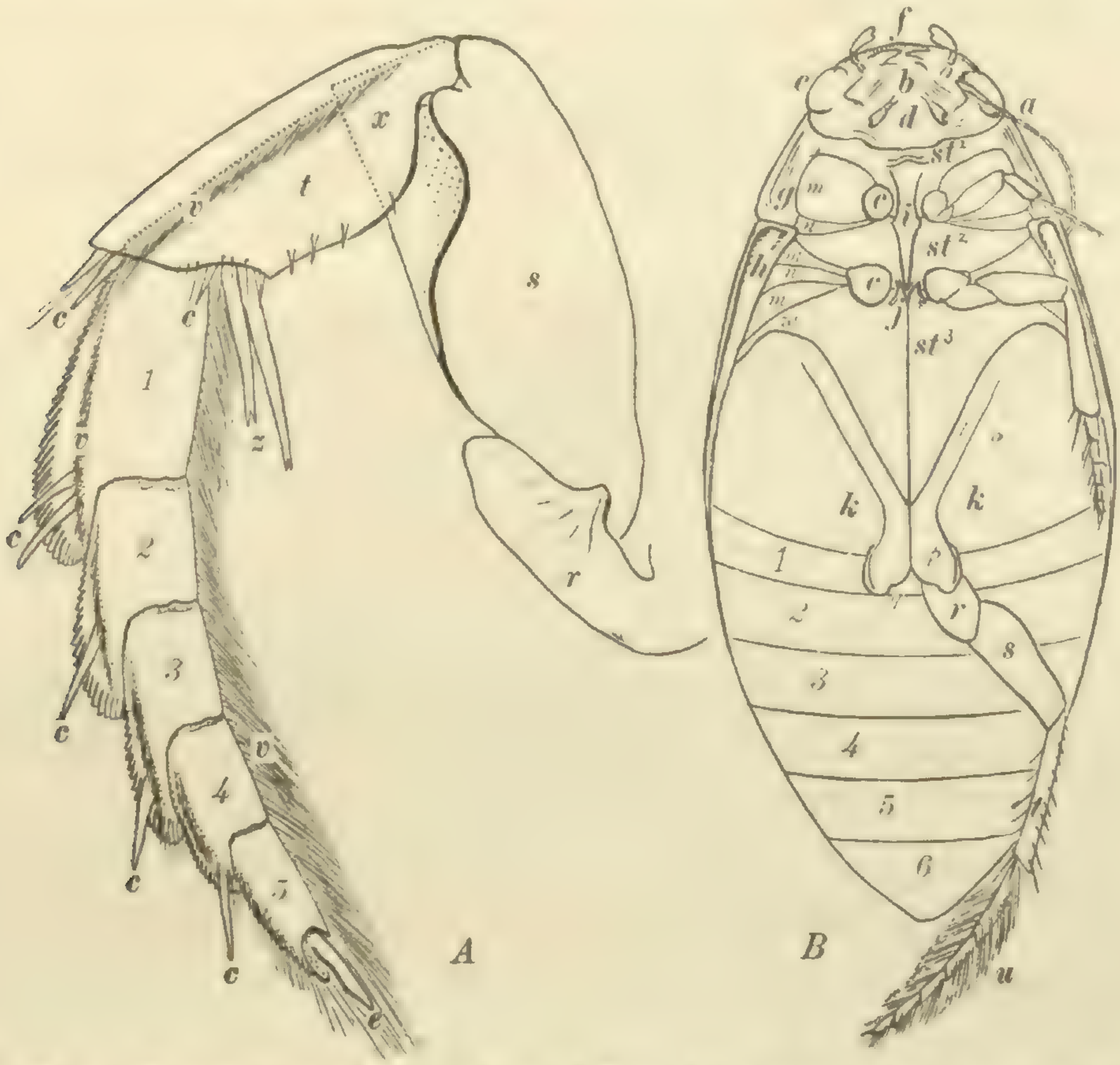


FIG. 2.— *A*, Ventral view of the hind leg of *Laccophilus maculosus*. *r*, trochanter. *s*, femur, and *x*, its prolonged posterior angle. *t*, tibia, and *z*, its spurs. *1*, *2*, *3*, *4*, *5*, tarsal segments. *e*, the single rudimentary claw. *v*, *v*, *v*, swimming fringes. *c*, *c*, *c*, *c*, *c*, *c*, jumping spines.

B, Ventral view of *Coptotomus interrogatus*. *a*, antenna. *b*, mouth. *c*, *c*, fore and middle coxal cavities. *d*, labial palpi. *e*, eye. *f*, maxillary palpi. *g*, lateral margin of pronotum. *h*, epipleuron. *i*, prosternal process. *j*, bifurcated intercoxal process of the metasternum in which is lodged the anterior end of the mid-ventral metasternal groove. *k*, *k*, hind coxæ; *l*, inner and *o*, outer laminæ of same. *m*, *m*, *m*, epistema of the three thoracic segments. *n*, *n*, epimera of prothorax and mesothorax. *p*, the coxal process, and *q*, the coxal notch in the right coxal process. *r*, trochanter. *s*, femur. st^1, st^2, st^3, sterna of the prosternum, mesosternum, and metasternum respectively. *t*, tibia. *u*, tarsus. *w*, wing of the metasternum. *1*, *2*, *3*, *4*, *5*, *6*, ventral abdominal segments.

The Structural Adaptations of the Beetles for Aquatic Life.— The ancestors of the Dytiscidæ were doubtless terrestrial, and probably they were not very different from ground beetles of the family Carabidæ. Coleopterists agree that the association between these two families is a very close one. If we compare any ground

beetle (as, for example, Calosoma) with any of the higher Dytiscidæ (such as Dytiscus) we shall see some marked contrasts in appearance, and some indications of the main lines that have been followed in the adaptation of the latter to aquatic life. The body of Calosoma is loosely jointed; its surface is provided with sensory hairs and is sculptured; its antennæ are prominent and hairy, and its feet are long and adjustable to every inequality of its path. Dytiscus on the contrary is compact of body and evenly contoured, pointed at both ends and naked, with slender hairless reversible antennæ, and stiff oar-like hind feet. There are three main features of this adaptation, namely an increased rigidity of the body, diminished resistance to the water, and an increased swimming efficiency of the hind legs.

The increase in the rigidty of the body has been accomplished by the compacting and coadaptation of the parts of the external skeleton. Close conjunction has been effected between the head and prothorax (through immersion of the head into the front of the latter); between the several segments of the thorax; between the elytra and the sides of the abdomen; between the front margin of the elytra and the prothorax; and between the two elytra along the dorsal suture: this and the joining with the sides of the abdomen combine to make the air chamber inclosed beneath the elytra water tight. These coadaptations which distinguish the Dytiscidæ from terrestrial Coleoptera have been well recognized by systematists, and are especially well discussed in Sharp's great monograph of the family Dytiscidæ.[1] Rigidity is demanded in the body of a diving beetle as in the hull of a boat. The means of securing it are most noteworthy in those parts where in other beetles we find great flexibility, as between the first two segments of the thorax. This particular articulation can be fully seen and appreciated only in a disarticulated beetle, some of the coadaptive structures being more or less concealed by parts external to them. It is technically described by Dr. Sharp (*l. c.* p. 219) as follows:

"The coadaptation of the various parts of the posterior aspect of the prothorax, to corresponding parts of the after-body and base of the wing cases is extremely perfect and very complicated; proceeding from below upward, we have first, the prosternal process (Fig. 2 *B*, *i*) stretching beyond the meso-

[1] On Aquatic Carnivorous Coleoptera or Dytiscidæ. *Trans. Roy. Dublin Soc.* for 1882.

sternum to be received in a metasternal groove; directly above the prosternal process we see a considerable protuberance or prominence which fits into the fork of the mesosternum; then come the posterior aspects of the coxæ, which fit into facets on the face of the mesosternum, and on a still higher level we have the transverse bridge closing the coxal cavities which fits into the interior of the mesosternum, while on the upper surface we find that the base of the mesothorax and scutellum are shaped so as to allow the hind margin of the pronotum to overlap and accurately fit them, while the shoulders of the wing cases are prominent, and rest on an expansion of the posterior face of the pronotum which is beautifully sinuate and emarginate to facilitate the coadaptation. This joining is so perfect in the higher forms, such as Cybister, that if after the prothorax has been detached from the after-body an attempt be made to replace it in its natural position, this is very easily effected; and it will then be found that the prothorax retains its position in spite of considerable efforts being made to dislodge it."

A diminished resistance to the water has been brought about in many ways,[1] notably by the rounding of the contours of the body especially at the neck and shoulders, so that it assumes a boat shaped form†; by the depression of the eyes†; by the loss of hair† and sculpture; by reversal of the antennæ; by recession of the fore and middle legs into the concavities beneath the thorax at the sides; and by the flattening of the hind legs in the horizontal plane†.

The increased swimming efficiency of the hind legs has also been brought about in many ways, the seven most striking of which are as follows,— the flattening down and soldering fast of the hind coxæ (Fig. 2 *B*, *k k*) to the ventral surface of the metasternum, transforming what is in other beetles a movable joint into a remarkably rigid supporting base; the bringing of the basal joints of the leg into one plane of action, limiting their movements, but increasing the range of motion in the one horizontal plane; the development of braces at the joints to further limit motion to one plane, making the leg more rigid and oar-like; the shortening of the proximal joints of the leg†; the lengthening of the joints of the tarsus† accompanied by the flattening of these joints and occasionally of the tibial spurs as well; the development of swimming fringes

[1] The features designated by a dagger in this and the following paragraph appear to be exact parallels of aquatic adaptations in mammals, as stated in Dr. Osburn's interesting article in the *American Naturalist* for October, 1903 (vol. 37, pp. 651–665). In many other respects it appears that by diverse means analogous results have been attained. That the changes in body are not more directly comparable in the two groups is due to the very great differences in the nature of the supporting skeleton.

in the thin lateral margins of the tarsus; the recurvature of the tarsi to a more dorsal position, in line with the motion of the center of gravity of the body †; and finally the loss of the hind claws†.

The modifications having to do with the taking and storage of air are much less obvious. They consist in the adjustments of the margins of the elytra (already mentioned for their compacting and strengthening function) which tend to make a water tight air-compartment; and in the slight modification of the tracheal system in a few members of the family (Dytiscus, etc.) manifest in the enlargement of the hindmost abdominal spiracles to several times the diameter of the other spiracles. The respiratory apparatus of terrestrial beetles has been evidently fairly adequate, and the main problem has been that of getting through the water with sufficient ease and speed to capture prey and to escape from enemies.

The Larvæ Studied.— Five species of larvæ of Dytiscidæ were kept under observation. Unfortunately but one of these (*Hydroporus undulatus* Say) was reared to the adult beetle. The others are here named tentatively, it being possible to make a supposition as to the genera to which they belong, based on the known fauna of the Gym pond, on their size, and on their likeness to known European forms. The largest larvæ encountered (41 mm. long) were those of Dytiscus. These are of the sinuous spindle-shaped form, well known from being figured in every entomological text book. We found them in May in great numbers, feeding on Corethra pupæ in the deep narrow straits of open water between standing aquatics, but they are so well known and they require such quantities of live food daily, that we did not attempt to rear them. Of still more snaky form and with an equally good development of swimming fringes on legs and the sides of terminal abdominal segments is the agile larva of Acilius. It is an exceedingly graceful creature, and has a remarkable capacity for dodging quickly when approached. Our specimens of this form were young (15.5 mm. long) and their nurture had to be abandoned before any of them had transformed.

The larvæ which we have referred tentatively to *Coptotomus interrogatus* (Fig. 3) are but poorly adapted for aquatic life: they are much more like primitive ground beetle larvæ of the family

Carabidæ. We obtained numerous specimens in the fall of 1905 when our cages were first started, and these furnished our early experience. The first lot collected, kept over night in a small vessel, ate each other; in the morning but one remained. The second lot, kept over night in a large vessel with plenty of proper food, did exactly the same. Then we made a screen cage with separate compartments, set it in an aquarium and put our third lot into it, one larva in each compartment. These then climbed out of the water and over the partitions and ate each other as the others had done. They did not mind a little ramble in the open air at all. By this time we had learned the necessity of covering the top as well as the bottom of each compartment: but unfortunately we were not then able to find any more larvæ. This is the more regrettable because no larvæ in this endemic American genus have been made known. A description of the larva is appended to this paper.

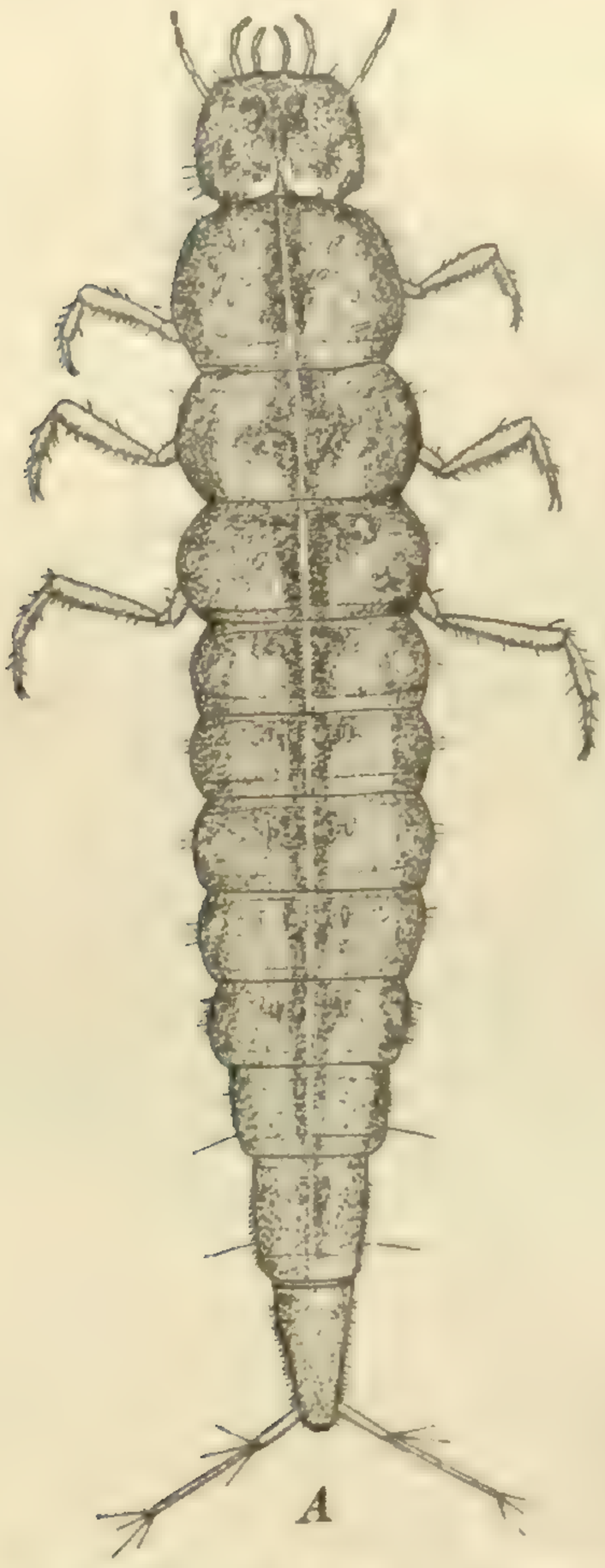


FIG. 3.— Larva of *Coptotomus interrogatus?*

We were fortunate in finding in the spring of 1906 grown larvæ of *Hydroporus undulatus* Say (Fig. 4), and in rearing them. These were taken from the pond May 20th and were kept in shallow water in a flat bottomed white dish containing a few dead leaves and bits of typha stems. Showing nothing of the disposition of the larger larvæ to eat each other, we left them together in the dish and fed them with small fresh pieces of damselfly larvæ. On May 29th four of the larvæ were found inactive and curled up on their backs on the bottom of the dish. These were placed on damp sand in a dish covered so as to be perfectly dark. They did not spin, nor make a cell, nor even move from the positions in which we placed them, but on June 2nd, two of them were found transformed to soft white pupæ of the form shown in Fig. 5 and two

days later the other two had transformed. On June 8th, the first one transformed to the adult beetle. A little later adults of the same species could be collected commonly from the edges of the pond.

The minute larvæ of Bidessus, apparently grown, were found so near the close of our work that there was no time for attempting to rear them. They are here referred to the commonest species of the genus from the same habitat, *Bidessus lacustris*.

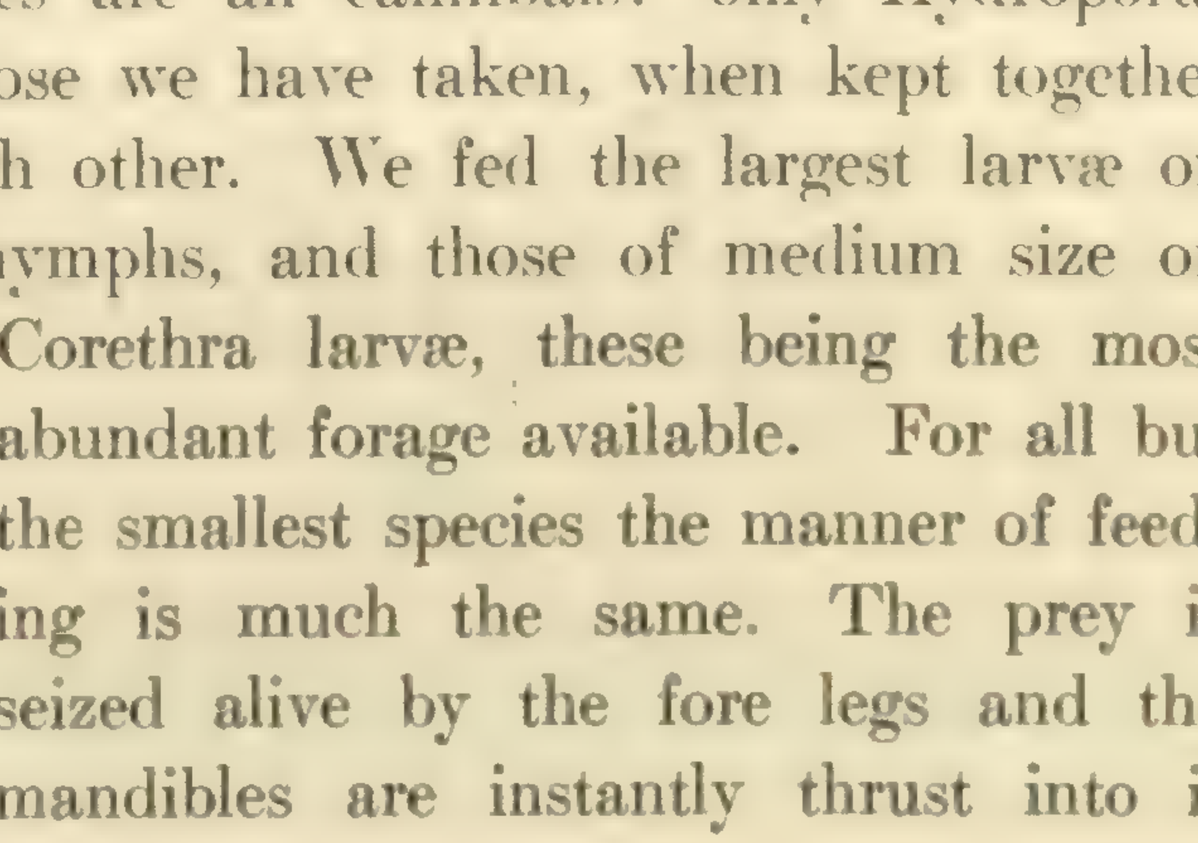


FIG. 4.— Larva of *Hydroporus undulatus*.

Habits of the Larvæ.— The larvæ, like the adults, are all carnivorous. The larger ones are all cannibals: only Hydroporus and Bidessus among those we have taken, when kept together refrain from eating each other. We fed the largest larvæ on damselfly and mayfly nymphs, and those of medium size on Corethra larvæ, these being the most abundant forage available. For all but the smallest species the manner of feeding is much the same. The prey is seized alive by the fore legs and the mandibles are instantly thrust into it deeply, and it is sucked until nothing remains but the empty skin. For the small Hydroporus larvæ we were unable to supply living prey of suitably small size: so, pieces of damselfly larvæ freshly cut up for the purpose, were used. These were seized between the long frontal horn (Fig. 6) and the upcurved mandibles, sucked for a little while, then dropped, to be returned to at intervals and seized and sucked again.

FIG. 5.— Pupa of *Hydroporus undulatus*.

The swimming habits of the different larvæ are remarkably different. Coptotomus (Fig. 3), having little development of swimming fringes, makes very violent and inefficient movements

of the legs and abdomen in swimming. When approaching the surface of the water the head is upward and the body advances by a succession of irregular shifts (Fig. 7 *A*, s). It rarely takes a direct course to the surface, and in water of more than a few inches depth, it has great difficulty in reaching the surface by swimming. It can remain below for a considerable time. Of half a dozen specimens transferred to a fresh aquarium and watched, the first to reach the surface came up in about four minutes, but went down again at once: the first to remain at the surface taking air, rose after twelve minutes: several did not rise for at least seventeen minutes. In taking air this species hangs vertically from the surface with legs limply extended, and with caudal cerci outspread upon the surface film (Fig. 7 *A*, *t*). When it leaves the surface, it swims downward head first in an indirect sinuous course. The tail appears not to be used at all as a fin in swimming. The larvæ of Dytiscus are possessed of an excellent swimming fringe along either side of the terminal abdominal segments, and they use their tails continually in swimming, lashing them violently back and forth, up and down. They swim to the surface head upward (Fig. 7 *B*, *v*), but quite as often they float slowly upward with both head and tail elevated, the former a little in advance, and with the body bent in a wide U-shaped curve. Usually when floating thus, bubbles of air may be seen sticking to their bodies. While taking air they retain this curved position (Fig 7 *B*, *w*), the top of the head as well as the caudal cerci resting in the surface film. These larvæ are powerful members of the natural society in which they live, and are much less easily frightened than other species. One of them that had been fed regularly for a few days would allow its back to be stroked gently with a pencil, and not until poked violently would it swim away: then it would

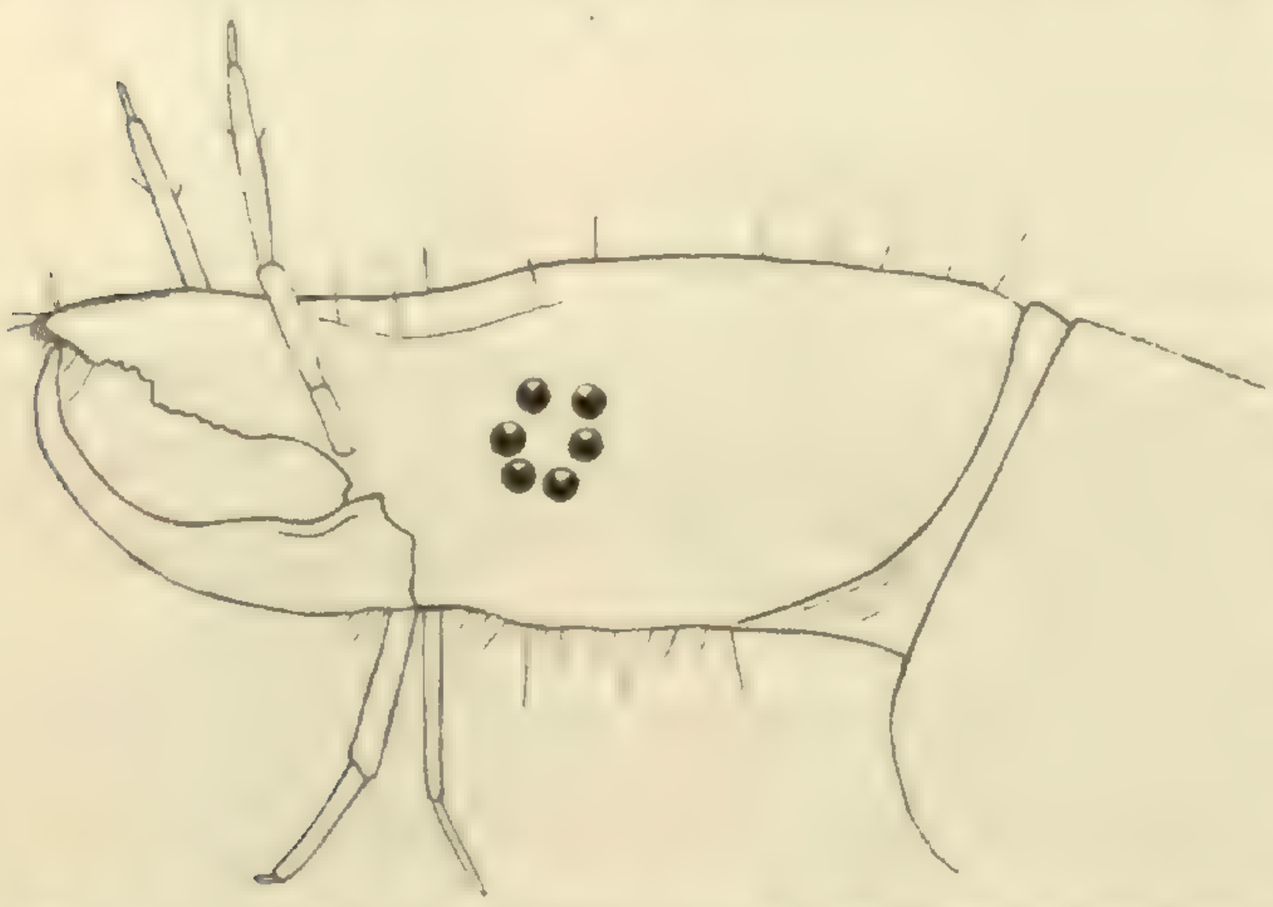


FIG. 6. — Head of larva of *Hydroporus undulatus* seen from the side.

swim very rapidly, as if in sudden alarm, with quick wriggling movements of its body and tail.

The larva of Acilius although much like that of Dytiscus in general appearance and in the possession of excellent swimming fringes, is very different in its habits. It has a peculiar way of swimming toward the surface tail upward, in a sinuous course as indicated in the diagram (Fig. 7 *C*, *x*) its progress being accomplished by very slight movements of its legs. Often one will start from the bottom swimming forward, then circle about horizontally once or twice, and finally rise to the surface, tail upward, as just described. This species swims very rapidly, twisting and turning its long slender body like a snake. When disturbed it

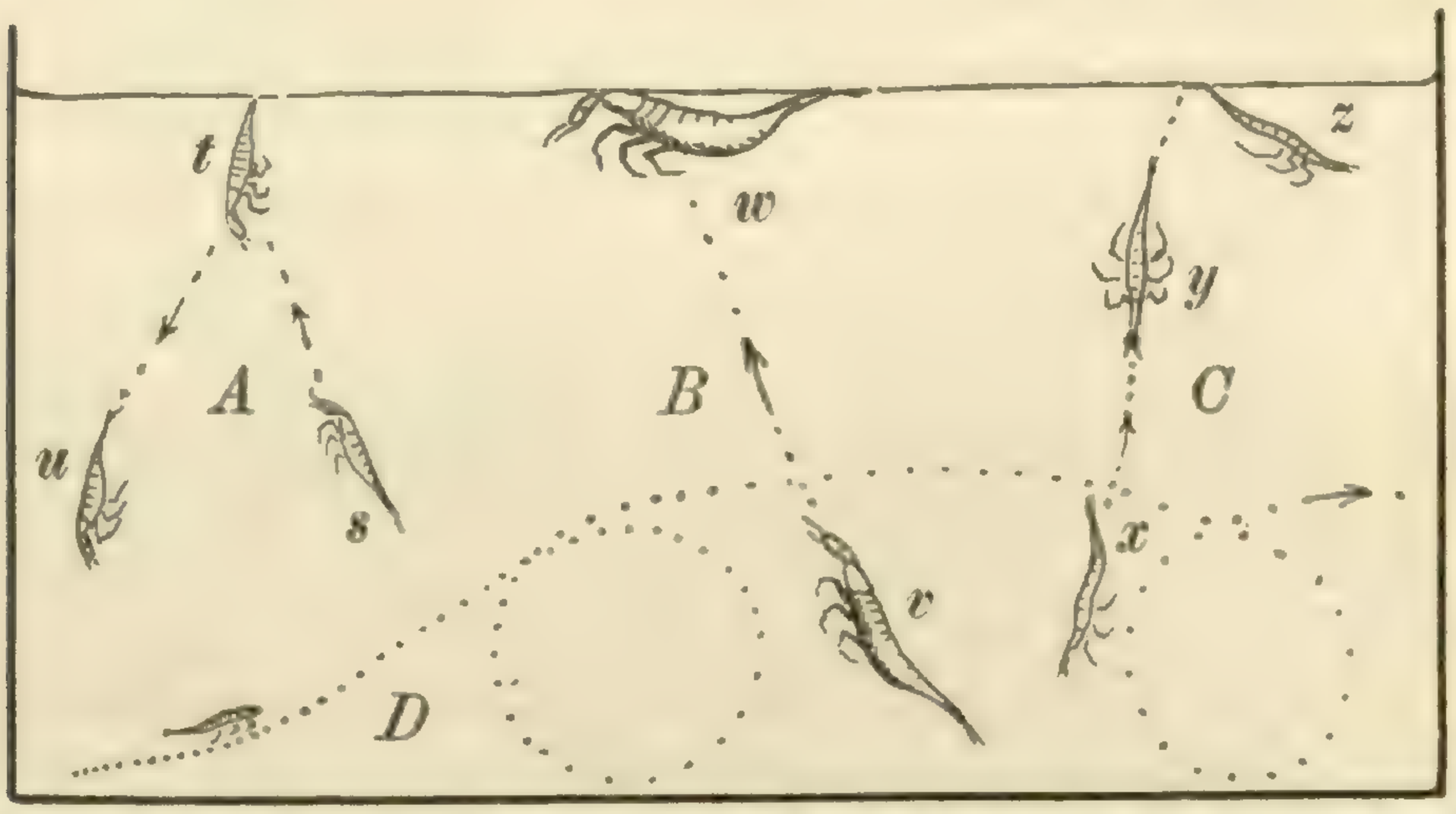


FIG. 7. — Diagram of swimming habits and attitudes of dytiscid larvæ. *A*, *Coptotomus interrogatus* *B*, *Dytiscus hybridus*. *C*, *Acilius sp.?* *D*, *Hydroporus undulatus*.

darts with a peculiar indescribable motion of the whole body away from the point of disturbance. Sometimes it makes just one quick dodge, and sometimes it goes through a series of wriggling movements so swiftly executed that the eye cannot follow them. This dodging feat must be of great advantage in avoiding enemies.

The larva of Hydroporus (Fig. 4) has only a scanty development of swimming fringes on its legs, and its tail is used merely as a rudder. It crawls much and swims little. It has a boomerang-shaped body, which when projected through the water, has a corresponding motion. It circles about in a vertical plane, its back to the outside of the curve, as indicated in the diagram

(Fig. 7 *D*). Placed in a deep vessel of clear water the Hydroporus larvæ spend much time swimming about in this manner, very rarely rising to the surface. During various periods of observation, none were seen to remain at the surface taking air: and during about an hour and a half of continuous observation of half a dozen specimens together in a large beaker, not one of them rose to the surface. When kept in a shallow dish of water with plant fragments, they spent much time crawling about on the bottom, creeping beneath dead leaves, or hiding in the hollows of the typha stems.

Supplemental descriptions of hitherto unknown larvæ of Dytiscidæ

1. **Coptotomus interrogatus** Fabr. (supposition). Length of larva: 17–18 mm., cerci 2 mm. additional, greatest breadth 2.5–3.0 mm.

Body elongate, rather stout anteriorly: head narrower than the prothorax, which equals the other thoracic and the first four abdominal segments in breadth: terminal segments of the abdomen tapering. General color brown above and on legs; below, paler.

Head depressed, the sides parallel for more than half its length, from the eyes to the spinous margined hind angles, behind which it is constricted to a short neck. Mandibles stout, prominent, channeled nearly to the base (Fig. 8, *g* and *i*). Maxillæ with two curved spines upon the inner face (Fig. 8, *a*) in a close fringe of short hairs, a sub-cylindric end segment, a four-jointed palpus and single terminal and dorsal setæ. Labium (Fig. 8, *e*) simple, its body trapezoidal, the anterior margin double-edged and the edges beset with fine short spinules, the second joint of the palpus bearing internally a long fine seta. Antenna (Fig. 8, *d*) four jointed, simple.

The general color of the head above is brown, with a pair of obliquely placed transverse pale marks between the bases of the antennæ; behind these, two small clusters of pale dots with yellow (marks between them and a pair of larger yellow dots behind them. On the occiput, a pair of larger ff. marks more or less confluent with the yellow of the hind margin stands between two more scattered clusters of pale dots, which extend in a line forward and outward to the eyes: outside these lines of dots is a yellow oblique stripe on each side above the spinous margined hind angles.

The prothorax is but little longer than broad, its sides are broadly rounded and its anterior end is constricted to form a short neck. In coloration it is brown above, with a median double row of more or less confluent pale dots abbreviated before and behind and not reaching the ends of the segment, and with a few widely separated, elongate hiero-

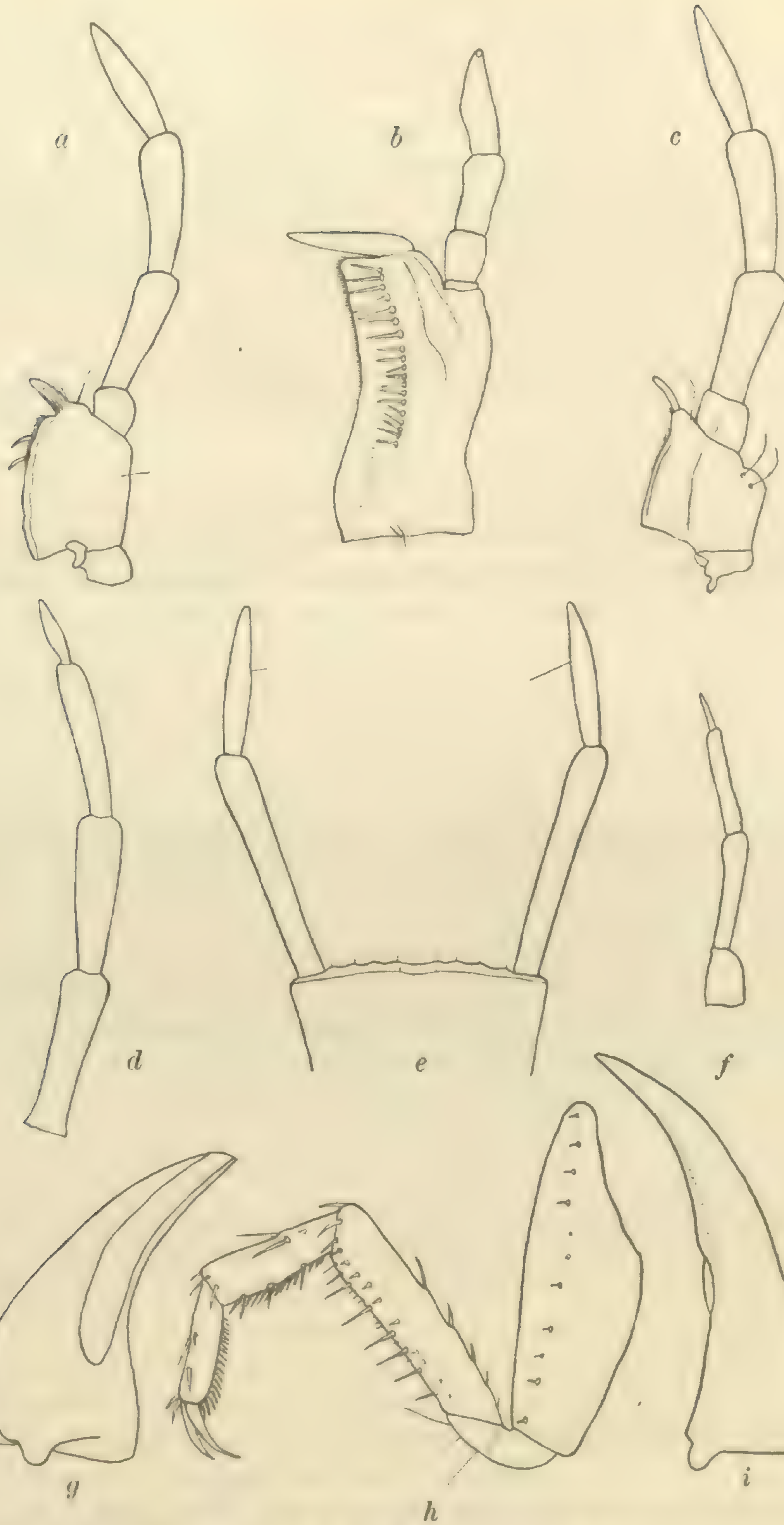


FIG. 8.— Structures of larvæ of Dytiscidæ. *a*, maxilla of *Coptotomus interrogatus ?* *b*, maxilla of *Acilius sp.?* *c*, maxilla of *Coptotomus longulus ?* *d*, antenna and *e*, labium of *Coptotomus interrogatus ?* *f*, maxilla of *Hydroporus undulatus*. *g*, inner aspect of mandible, *h*, fore leg and *i*, outer aspect of the mandible of *Coptotomus interrogatus?*

glyphics on the disc each side. On the succeeding segments, which are about two thirds as long, there is only one pair of pale submedian dots and these are placed close behind the anterior transverse carina: and there are a few pale markings outside these on each segment, the innermost one of which each side becomes resolved into a single longitudinal dash on the abdominal segments. All these markings disappear on the hindmost segments, which are uniformly deeper brown. The legs are brown with narrow darker lines across the tips of femora and tibiæ. The spiracles are set in the uninterrupted lateral margin of the dorsal shields on the middle abdominal segments.

The basal abdominal segments are of nearly equal length. The length increases slightly successively on segments 4, 5 and 6 and rapidly on 7 and 8, each being one half longer than the segment preceding it. There are a few slender setæ about the lateral margins of all the body segments except the hindmost, and that segment is thickly beset all over its dorsum with short stout spinules. The respiratory tubercle is short and obtusely truncated: viewed from the side it is conspicuously and obliquely prolonged over the bases of the cerci. The cerci are about as long as segments 7 and 8 together, two jointed, the second joint being about three times the length of the basal one: at the tip of the basal segment are two or three slender setæ, and at the tip of the terminal one four more.

2. **Coptotomus longulus** Lec. (supposition). While this study was in progress the larvæ of a second species, so closely similar that it probably belongs in the same genus, were received from Professor T. D. A. Cockerell, collected by him from the Gallinas River, Las Vegas, N. Mexico on the 12th of Jan. 1902. These are like the ones just described in size, and in general coloration, though the color pattern is less sharply defined. They differ in lacking the curved spines from the inner face of the maxilla (Fig. 8, *c*) and in the relative length of the segments of the cerci, the second being hardly twice the length of the first.

3. **Hydroporus undulatus** Say. Length 6 mm.; cerci, 1 mm. additional; greatest width about 1 mm.

Color brown above, whitish beneath. A narrow middorsal line of pale yellow extends from the middle of the head backward the length of the body: it is somewhat interrupted by the dark brown posterior margins of the middle abdominal segments. On the front of the head this pale line is dilated to include three brown spots: a pair of U-shaped spots between the eyes, the arms of the U's extended backward, and a median spot on the base of the rostrum. There is a lateral row of large pale spots beginning on the side of the head, where it encircles the eye, and ending on the eighth abdominal segment. These spots are elongate and jagged on the inner margin on the thoracic segments but rounded and diminishing in size posteriorly on the abdominal segments. The antennæ and legs are pale. In the brown of the rear of the head between the median

and lateral spots are three minute yellow dots each side: these are often confluent.

The dorsal plates of all the body segments are thinly clad with slender fragile setæ: the hind margin of each abdominal segment bears a fringe of stouter setæ: the fringe is much shorter than the length of the segment.

The cerci are slender, tapering, longer than the seventh and eighth abdominal segments taken together: they are studded externally with thin and scattering setæ and bear at the tip a little cluster of a few setæ, the central one of which is much stouter than the others and appears as a prolongation, or as a second tapering cercal segment.

The rostrum (Fig. 6) is as long as the head, broad and obtusely rounded at the tip, indented just beyond the middle of each lateral margin, with the broader more flaring edge behind the indentation fringed with excessively minute and slender setæ of which there are several transverse rows that extend across the dorsal surface.

The coxæ are somewhat longer than the femora. The femora, tibiæ and tarsi are armed with stout spinules beneath, and tibiæ and tarsi bear also scanty fringes of longer hairs externally.

The mandibles are long and sickle shaped, and are perforated nearly to the upturned tips, which rest just beneath the tip of the rostrum. Maxillæ greatly reduced, laciniæ and galeæ being wholly wanting (fig. S *f*). Labium projecting, mentum narrow, trapezoidal, widened anteriorly, the slender nearly naked two-jointed palpi arising from the square cut front border near the outer angles: at the middle of the terminal joint of palpus are two slender setæ and four or five arise about the base of the first joint.

4. **Bidessus lacustris**. Length 3.5 mm: width .6 mm.

Color grayish brown, faintly marked with grayish yellow, the latter color predominating on the head and on the hinder abdominal segments. Body beneath and all appendages pale. The brown of the head and prothorax forms a large dorsal X whose anterior arms end between and close to the eyes, whose large posterior arms reach backward beyond the middle of the prothorax and are incurved at their tips. Between them arises the stem of a T-mark whose top bar occupies the hind margin of the prothorax. Meso- and meta-thorax with an obscure brown mark each side. Abdominal segments suffused with brownish, and having an indistinct divided pale transverse bar across each except the last.

The respiratory tubercle of the eighth abdominal segment is triangular pyramidal, and continues the slope of the sides of the segment to a subacute tip, and is about half as long as the body of the segment. The cerci are slender and tapering. They are armed with a pair of long setæ externally at one third their length, opposite the tip of the respiratory tubercle, another single external seta at two thirds their length, and at the tip is another external one close beside two internally placed and

similar ones, and a central stouter seta that continues the taper of the appendage and is attenuate to an excessively slender tip.

The general pubescence of the body is short, dense and scurfy: that of the legs is shorter and stouter. On the hind borders of the abdominal segments there is hardly any differentiation of apical fringes.

The rostrum is longer than the head, broad and obtusely rounded at its tip, where it bears a fringe of very fine close-set setæ, suddenly broadened opposite the bases of the antennæ where the heavy pubescence of the body begins, and toothed beneath at midway the length of its lateral margins. The mandibles are somewhat constricted just before the tip and bear a ring of scattered setæ about the constriction.

This larva differs from that of Hydroporus most markedly in the dense pubescence of its body, in the possession of longer tarsal claws — claws as long as the tarsus itself, and in the continuity of outline of the sides of the eighth abdominal segment with the respiratory tubercle, there being no constriction setting off the latter at its base.

BIOLOGICAL LABORATORY
LAKE FOREST COLLEGE

HABITS OF THE SHORT-TAILED SHREW, *BLARINA BREVICAUDA* (SAY)[1]

A. FRANKLIN SHULL

Introduction.

In January, 1906, in a low tract of land near Ann Arbor, Professor Jacob Reighard found upon the snow a number of heaps of snails of several species of the genus Polygyra (Fig. 1). At his suggestion and under his supervision I undertook to find what had heaped these shells and to pursue any further studies suggested by the discovery. I am also indebted to Mr. Bryant Walker for identifying a number of snails.

The heaps contained from two or three to more than a hundred shells. During the whole period of observation five species were found represented,— *Polygyra albolabris*, *P. multilineata*, *P. profunda*, *P. thyroides*, and *P. fraterna*, in the approximate ratio of 300:250:30:1:8. On several successive excursions the number of shells in individual heaps was counted, and it was found to vary; shells had either been taken away or added. No marks were visible in the snow to tell how the shells had been moved, but there was invariably the opening of a small burrow near the heap. My problem was to discover what animal was moving the snails, and also something of its habits.

Finding the Shrew.

The presence of a burrow at each heap and the absence of marks in the snow suggested that the occupant of the burrows was moving the shells. To determine this point, bacteria dishes were inverted over each of several of the heaps of snails together with the adjacent burrow. The snails were found to be moved just as before. A further test was made as follows:— A heavy wire

[1] Contributions from the Zoological Laboratory of the University of Michigan No. 112.

was passed through a spool and bent down at the ends in the form of an inverted U. The sharpened ends of the wire were thrust into the ground. The spool was held in such a position that a thread unwound from it could easily pass into the burrow. On the reel thus formed were wound several yards of carpet thread, to the end of which a snail was tied by means of a hole pierced through its shell just back of the lip. The shell was then placed near the opening of the burrow. The thread was marked at intervals so that it would be possible, without first finding the shell, to determine how much had been reeled off. At the next visit to the heaps the thread was found extending into the burrow for about a foot. The shell was still fast to the string, but had been broken open and the snail was gone.

Now that I knew where to look for the animal, I began to set traps. At one place there were two large heaps of shells about a meter apart, each near a burrow descending abruptly into the ground. Between these was a well worn path in the snow at the surface of the ground. Into this path a steel wire trap was sunk by digging out a bit of the earth, so that the trigger of the trap was on a level with the bottom of the trail. No bait was used. At my next visit the trap contained a short-tailed shrew, *Blarina brevicauda*. Many of the snails had been removed, showing either that the animal had for some time escaped the trap, or that another shrew had carried on the work after the first had been captured.

My work was then ordered according to the following plan: (1) To discover as many heaps of snails as possible in different situations, and to record minutely the changes in location of the shells above ground; (2) As soon as the frost had thawed out of the ground, to excavate the burrows and search for nests; (3) To capture in the meantime one or more shrews and confine them in the laboratory; and (4) To make various psychological studies in the laboratory and in the field.

OBSERVATIONS ON THE HEAPS OF SNAIL SHELLS.

All my field observations were made in Steere's swamp, a tract four miles south of Ann Arbor. It was here alone that the heaps of snails were found, though search was made for them at other

places where the shrew had been taken. The soil of this region is rich black peat, at many places in a rather early stage of decomposition. The groundwater level in spring occurs at a depth of only 15 to 20 cm., so that after even moderate rains the water stands at the surface in places for several days. Several ditches have been dug through the swamp. Near these the groundwater level sinks gradually to the level of the water in the ditch, which was usually 60 to 70 cm. below the surface at the season when my observations were made. According to old settlers, the region

FIG. 1.— A heap of 19 snail shells near the opening of a burrow of *Blarina brevicauda*. This burrow is not visible, the large one beyond the heap belonging to another animal. The shells are in a slight depression where the snow has not melted.

was formerly occupied by tamaracks, black ash, and willows. Since it was cleared a few years ago, nettles, goldenrod, and sumac, with here and there a thicket of black ash, willows, elder, and raspberry, have taken the swamp.

Apparently the region favors the growth of snails, for they are abundant. Many live ones were found after warm weather had set in, and large numbers of empty shells were scattered over the surface. Within two areas containing the principal thickets and goldenrod patches of the swamp, each less than 150 meters in radius, there were found, by careful search, a total of over forty heaps of shells. The larger portion of these was being moved. Of those shells that were not being moved, a number were cracked.

They may have been broken before the shrews began collecting them; they may have been accidentally cracked in transportation; or the shrews may have broken them purposely, to render the snails immobile. This effect was produced by compressing some snails in a vise until their shells were cracked much like those in the field. These snails were placed with uninjured ones on moist earth in a warm situation; the latter were soon crawling about. Those with broken shells never came out although for three weeks they contracted in response to thrusts with a stick, showing that they were still alive.

The shells at the various heaps were either occupied or empty. The number of both sorts was being increased in certain heaps which were receiving additions. When, at another time, shells were being removed from these heaps, only the number of occupied shells was diminished, whereas that of the empty shells remained the same. To determine whether this distinction occurred regularly, a considerable portion of the shells was numbered. The figures were placed near the base of the columella, since in all the broken shells that had been observed up to that time this portion remained intact. At each visit, the numbers of the shells at individual heaps were recorded, and when they were not too numerous, their relative position was carefully mapped. A record was kept of the condition of the shells, whether they were occupied or empty, entire or broken, at the time of numbering. As new shells were added to the heaps, they were numbered.

From Feb. 15 to Apr. 7, 144 shells found in the field were numbered. Of these, 99 were occupied, and 45 were empty, most of the latter being unbroken. To increase the number under observation, 25 snails that had been killed in formalin and then transferred to alcohol were added to the various heaps where the number of shells was found to vary. At the end of this period of more than seven weeks, the records showed that the following disposition had been made of the shells:

TABLE I. Showing the number of occupied and empty shells, also snails killed in formalin, which were removed from the surface, and the number left at the surface.

Condition of shells.	Number of shells.	Number of shells removed.	Number of shells left.
Occupied	99	76	23
Empty	45	2	43
Formalin	25	7	18

It is seen that most of the occupied shells were removed, although but few of the empty ones were ever taken away. The formalin snails show neither extreme, though the majority were untouched. Apparently the shrews have some method of distinguishing between an empty shell, a normally occupied one, and a snail killed in formalin. Experiments to determine the basis of this distinction are described under the head of Psychology.

The numbering of the shells served also to show the relation between the activities of the shrews and climatic conditions. The climatic data are from the Observatory of the University of Michigan. Humidity was not recorded but it seems hardly probable that the absolute humidities possible at the low temperatures that prevailed would have any marked effect. The temperature readings on days when field trips were made, and the observations on the shells for a period of seven weeks are given in Table II. The shells here included were brought to the surface of the ground at 21 different points on an area not more than 8 meters in diameter. Two shrews were eventually captured at this place, and subsequent excavation of the burrows within this area revealed but one nest. I have concluded, therefore, that the heaping up and removal of all these shells was probably the work of a single pair of shrews. My field trips were made sometimes in the forenoon, sometimes in the afternoon. I nearly always visited this small area first, since it lay on that side of the swamp nearest Ann Arbor. I then passed on to the more distant parts of the swamp, and returned to the same area some three hours later, again carefully noting the arrangement of the shells. In only one instance did I find that any shells had been moved during the three hours, and then three shells were brought to the surface in the forenoon. From these facts I have concluded that most of the shells are moved at night. In the table, therefore, I have given the minimum tempera-

ture of the night, rather than the maximum or the average. The Fahrenheit scale is retained as given in the weather records. The snails killed in formalin which were placed at the burrows in this area are not included in the counts.

TABLE II. Showing the number of shells at the surface in an area 8 m. in diameter, and the minimum nightly temperature, for a period of over seven weeks.

Date.	Minimum temperature °F	Number of shells at surface. Occupied	Empty	Total	Change in total number of shells since last visit.	Change in minimum temperature since last visit.
Feb. 15	2	61	13	74	....	....
20	30	32	17	49	— 25	+32
22	29	28	18	46	— 3	— 1
24	38	33	18	51	+ 5	+ 9
27	14	146	23	169	+118	—24
Mar. 1	23	118	24	142	— 27	+ 9
2	26	....	....	....	....	....
3	31	....	....	....	....	....
4	25	....	....	....	....	....
5	23	....	....	....	....	....
6	19	72	25	97	— 45	— 4
8	32	52	25	77	— 20	+13
10	25	59	25	84	+ 7	— 7
13	16	56	25	81	— 3	— 9
15	14	57	25	82	+ 1	— 2
20	16	60	25	85	+ 3	+ 2
24	8	59	27	86	+ 1	— 8
27	35	29	32	61	— 25	+27
31	25	26	32	58	— 3	—10
Apr. 3	35	24	32	56	— 2	+10
7	37	16	32	48	— 8	+ 2

As in Table I it is seen that the number of empty shells was never diminished, showing that once the empty shells were brought to the surface they were not ordinarily moved again. Throughout the seven weeks there is a steady increase in the number of empty shells. If the last two columns be compared, it is observed that on ten of the sixteen days the change in temperature and the change in the number of shells are of opposite sign, — that is, with a rise in temperature shells are removed and vice versa. These ten days include all the most marked temperature changes, namely, those on Feb. 20, Feb. 27, Mar. 8, and Mar. 27. Similar to these are the changes for Mar. 1 and Apr. 3. The conspicuous exceptions are Feb. 24 and Mar. 31, when, though the temperature

changes are marked, the change in the number of shells is of the same sign as the temperature change. Further, with the one exception of Mar. 6, all the considerable changes in the number of shells occurred at times when the temperature changes were of opposite sign. On this date there seemed to have been a marked removal of shells into the burrows, while at the same time the temperature had fallen. However, five days had elapsed since the last preceding visit. In this time there had not been a steady decline of the temperature; but the temperature had risen 8° between Mar. 1 and Mar. 3, and then fallen 12° from Mar. 3 to Mar. 6. Had I observed the shells on Mar. 3, the number of shells might have been much smaller than for Mar. 1, and then increased to Mar. 6. This seems especially probable since some of the individual heaps showed an increase on Mar. 6, and others a decrease. The decreasing effect of the rise of temperature prevailed.

Nests and Burrows

The Burrows.— The record of the snails was closed Apr. 7. Though a few occupied shells were still above ground, the weather was then so warm that several of the snails were found crawling about. Records of their transportation were untrustworthy after that time, and were discontinued. By this time the frost was in large measure out of the ground, and excavation of the burrows was begun. Two methods were employed. Where the ground was not very wet, flour was sometimes blown into the burrows with a small hand bellows. The burrow was then carefully opened as far as the walls were whitened, and more flour was blown in. If the ground were wet, the flour soon became moistened and lost much of its whiteness. A more successful method was to pass a rather stiff rubber tube into the burrow to keep it open while the spade was being used.

Some difficulty was experienced at first in determining which burrows were those of the shrew. The runs at the surface in which the shrew was trapped looked exactly like those of the meadow vole, or field mouse, *Microtus pennsylvanicus*. Moreover, I have seen Microtus enter burrows that descended abruptly

into the ground, so that it could not be said with certainty that even the underground burrows were those of the shrew. Further, I have found underground nests used by Microtus, notwithstanding the emphasis which Rhoads (1903, p. 100) places on the statement that the nests of this species are built "*at the surface.*" The position of any nests that might be found could not then be used as a safe criterion. Some of the burrows had heaps of shells near them, which could serve as the criterion if it were known that Microtus never used snails for food. To determine this point, two meadow voles were confined in iron cages in the laboratory. Each was given a vessel of water, and equal care was taken to keep each cage clean and dry. One Microtus was given corn, wheat,

FIG. 2.— Diagram of a typical burrow of *Blarina brevicauda*, showing distribution of snail shells, and an underground storage chamber with spiral descent. The upper figure is a horizontal projection; the lower an ideal vertical section. The black circles in the upper diagram are points where the burrow descended abruptly into the ground.

crackers, bread crumbs, etc., the other only a few live snails. At the end of 30 hours the latter Microtus was dead, but the former lived for several days, when it was removed from the cage. Fearing that such an early death might have been due to injuries received in capture, I confined two other voles in similar cages. Each was given only water and snails. One died in 48 hours, the other in 56. Later eight voles were captured and kept in confinement for a week to insure that they had not suffered injury while being captured. They were all in excellent condition at the end of this time. They were then confined in pairs successively, one of each pair being given its common food (grains, crackers, etc.), the other

only water and snails. In each case the one confined with snails died in less than 48 hours, the other remained in good condition. From these experiments I have concluded that all burrows with snail shells in or beside them were at one time used by the shrew. Taking this as the only criterion at first, I found other features later which distinguished the burrows of the two animals.

The burrows used by Blarina were usually 25 to 30 mm. in diameter. Those at the surface were exactly like those of Microtus, running in zigzag fashion under weeds and grasses, often pushing the latter aside, sometimes crushing them down, crossing and re-

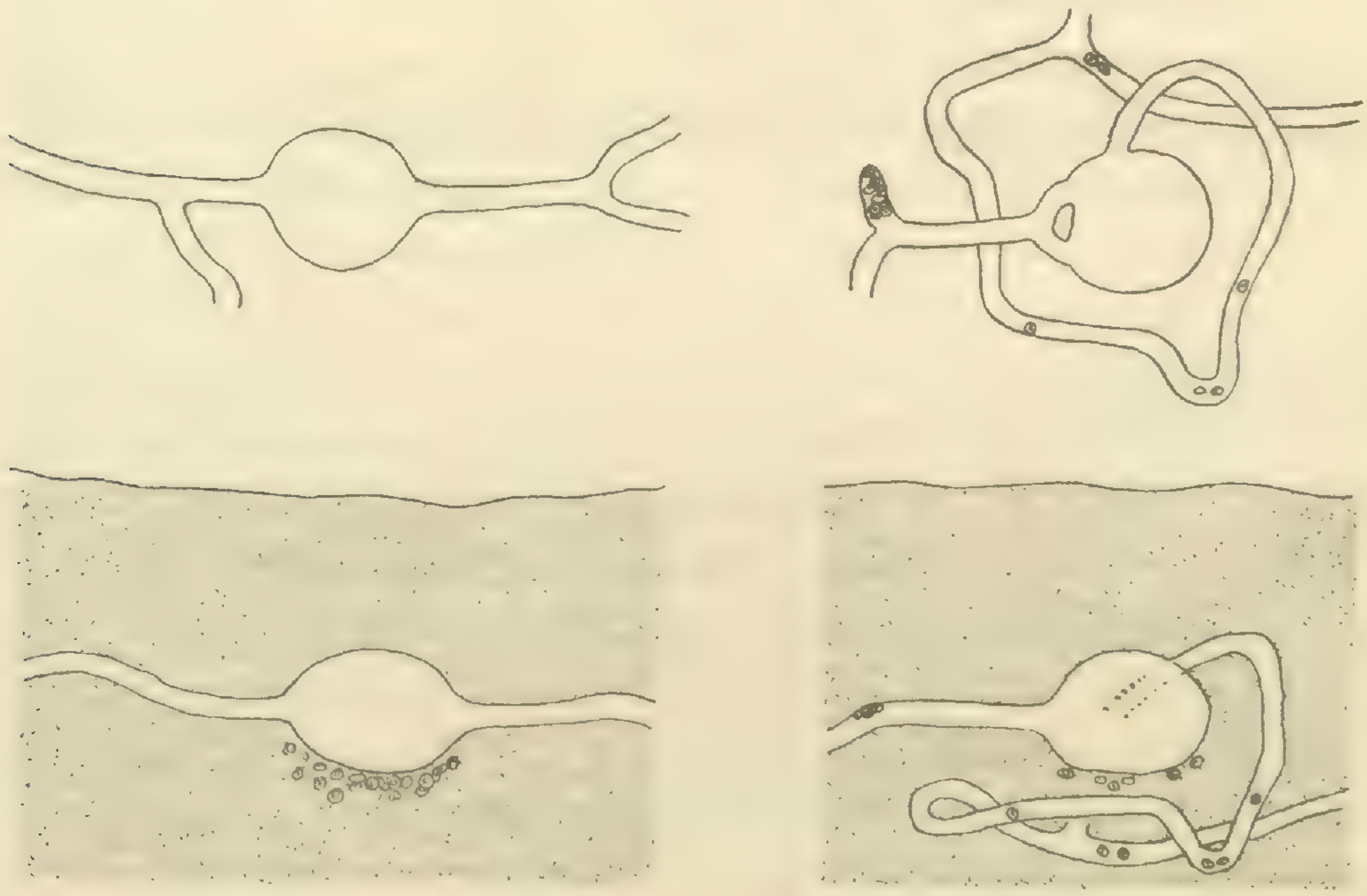


FIG. 3.— Diagrams of two nests of *Blarina brevicauda* and the burrows near them, showing distribution of snail shells. The upper figure in each case is a horizontal view; the lower an ideal vertical section.

crossing to form a complex network which in several cases was easily traced for 30 meters. When the burrows entered the ground, they did so at a steep angle, as Kennicott (1857, p. 94) has described. After descending 15 or 20 cm. they became more nearly horizontal, and passed along between 3 or 4 and 40 cm. below the surface. Branches were frequently sent off, at almost any angle. There was no ridge of earth above the burrow, even when the latter came near the surface, though Stone and Cram (1902, p. 181) mention such ridges. A typical burrow is represented in horizontal view and in ideal section in Fig. 2. Usually the burrows returned to

the surface, rising as abruptly at one end as they had descended at the other. The two openings of a single burrow were never found closer together than a meter, and they were occasionally four meters apart. This fact gives another means of distinguishing the burrows of Blarina from those of Microtus. As far as I have observed, the openings of an individual underground burrow of Microtus were never as far apart as a meter, usually not more than 35 or 40 cm. Microtus burrows, moreover, were not found to extend as deep into the soil as those of Blarina.

Nests and the Burrows Near Them.— Nests are found along the course of the burrows. In digging out the burrows some sixteen nests were unearthed. Some of these were along ditch banks where the groundwater level was lower than elsewhere. All the others were in small elevations such as mounds where celery had been buried or hills thrown up by roots of fallen trees. The nests were found at depths of 15 to 40 cm. They were 12 to 15 cm. in diameter, and slightly depressed from the spherical form. They were usually made of grass, sedge, and leaves of nettle, goldenrod or ash, arranged in the form of a hollow ball, the shell of which was 1 to 3 cm. thick. One was composed entirely of hair which microscopic examination showed to be that of the meadow vole. When plant materials were used, the plants furnishing them were invariably found immediately adjoining the nest. If grass was near the nest, it was used almost to the exclusion of other leaves. Coarse materials were used without being shredded or torn into smaller pieces. This constitutes an easy distinction between the nests of Blarina and such nests of Microtus as are constructed of anything larger than grass. In all the nests of Microtus which I observed, coarse materials were torn apart; sedge leaves 6 to 8 mm. wide were shredded into three or four strips, and corn blades and leaves of trees were torn into irregular pieces of any size less than about 2 cm. When the same kinds of material were used in Blarina nests they were in no way subdivided.

FIG. 4.— Excrement of *Blarina brevicauda*. Natural size.

Very rarely, in the vicinity of nests, the excrement of Blarina was found. In the laboratory, the excrement was piled up in the corners of the cage, but the only deposits found in the field occurred

singly. The excrement was greenish black when fresh, slightly brownish when dry. It was voided in spindle-shaped portions 25 to 30 mm. long, coiled in various ways, as in Fig. 4. Very different is the excrement of Microtus, which is found in black or brown spindles only 5 to 8 mm. long.

Usually two, three, or four burrows radiated from the nest. At one nest, however, no burrows could be found. I had followed an ordinary burrow with a rubber tube until the burrow seemed to come to a blind end; the tube could be pushed no further in any direction. Another burrow running obliquely to this one was then excavated. When I had approached within about 35 cm. of the place where the first burrow had been abandoned, the second burrow also was closed. A third burrow approaching the same spot was next dug open, and it likewise ended blindly. A spade was set in at the point toward which the three burrows converged, and at the first spadeful a nest was turned out. The partly eaten body of a meadow vole near by showed that the nest was then being used, and was not a relic of the preceding year. Careful search all round the nest failed to reveal a burrow leading to it. The soft, loose soil was then carefully dug up to a distance of 40 cm. around the nest and 20 cm. below it and examined as it was thrown out to discover the shrew. None was found, so the soil was thrown back and stamped down. At my next visit a burrow opened to the surface directly over the former location of the nest, showing where the shrew had escaped. It had evidently been present when I dug up the nest, but had escaped my spade. In this case I have concluded that the shrew was obliged to force its way through the mass of loose soil for a distance of about 40 cm. every time it entered or left the nest.

At one nest, in addition to three horizontal burrows radiating from it, a fourth was traced obliquely downward from the bottom of the nest, at an angle of about 40° with the horizontal. At a distance of about 60 cm. from the nest it terminated blindly.

At all but one of the sixteen nests unearthed, snail shells were found stored beneath and at the sides of the nest. All the shells at the nests were empty at the time of excavation, between Apr. 10 and June 10. Their number varied from two or three dozen to 166. Empty shells were also scattered at irregular intervals along

the burrows. Sometimes they were thrust into the soil at the sides of the burrow in groups of 2 to 10. At other places short branches led either downward or laterally from the main burrows, and then expanded into chambers filled with shells, mingled with loose soil. Such chambers contained in some cases as many as 80 shells. Generally, all the shells were empty, but one such chamber contained 69 shells, of which 54 were still occupied the last week in April. In several instances when such a chamber was located beneath the main burrow, the branch burrow leading to it was spiral in form, like a winding staircase. One of these is illustrated in Fig. 2. In two instances empty shells, broken exactly like those found elsewhere, were found inside nests which, from their composition of shredded material and position at the surface of the ground, must have been Microtus nests.

Method of Burrowing.— The method of burrowing was observed and experimented on in the laboratory, where a shrew captured by hand was kept for some time. When it was first confined, loose black soil was placed in the cage to a depth of about 10 cm. Into this soft soil the shrew at once thrust its nose, and by violent backward and outward strokes of its forefeet, forced its way through the soil like a wedge. No difficulty was experienced in burrowing 20 or 30 cm. in a minute. The movements underground were evidenced by the movement of the soil at the surface; but no ridge was formed above the burrow. When clods were encountered, they were readily moved, even if fifteen or twenty times as large as the shrew and proportionately much heavier.

During the first night a rather elaborate system of burrows opening to the surface at seven or eight points was worked out. The aggregate length of burrow was not known, as I did not dig out the soil, but it included the whole cage which measured 35 by 48 cm.

Some time later the shrew was put into another cage in which sandy soil had been placed. The same method of procedure was followed in attempting to make burrows, but small headway was made. I watched the shrew for half an hour, during which time it had not succeeded in getting under the surface. The next morning a burrow 15 cm. long open at both ends was found. At the end of a week there was an aggregate of 55 cm. of burrow

with three openings. An extension of 40 cm. had been made from one of the former openings. This sandy soil had not been packed. Hence the difficulty in burrowing in it must have been due to its weight, not to its hardness. In neither the black nor sandy soil did the shrew loosen the soil with its teeth as Kennicott (1857, p. 94) has conjectured. Neither then nor at any other time during the confinement of the shrew did I observe any marked surface runs which the animal was in the habit of following. Instead, it ran about anywhere in the cage.

Food.

Dietary of Blarina.— Two articles of food of Blarina have been so far mentioned, namely, snails and voles. A fair idea of the extent to which snails are used as food may be gathered from the data presented in Table II. On Feb. 27, there were at the particular series of burrows represented in this table 146 occupied shells. On Mar. 1, one of the two shrews which were found in possession of the burrows was captured, so that the succeeding work was that of one shrew. By Apr. 7, all but 16 of these snails, that is, 130 in all, had been removed underground. When the final excavation of the burrows was made at the end of April, all these shells were empty. One shrew must, therefore, have eaten 130 snails between Mar. 1 and the last of April.

The only quantitative evidence obtained in the field in regard to the vole diet was found at the nest mentioned above as having been made exclusively of the hair of this animal. Beside this nest, thrust into the loose peat, were the bodies of two freshly killed meadow voles and that of a third half eaten. In addition to these there were several handfuls of hair in which were mixed legs and tails enough for about twenty voles. I could not know how long it had taken to accumulate this mass. The hair was still moist, but was packed so close that moisture would be retained a long time even in the dry soil in which the nest was located.

To determine more accurately the quantity of mice and other foods eaten by the shrew, experiments were made in the laboratory. A shrew was kept in confinement for over five weeks, in a wire

covered cage in which earth was placed to a depth of about 10 cm. When practicable, live food was furnished. Among the various foods tried were meadow voles and house mice (*Mus musculus*), May beetles (Lachnosterna) and their grubs, moth larvae, other insects and pupae, earthworms, snails, sowbugs, carrots, crackers, roots of grasses and other plants. None of the last three articles were ever touched as food. If any article proved especially acceptable to the shrew, that food was furnished exclusively for several days, and the quantity consumed was noted. From these figures the average per day was computed. The result in each of the foods thus tested is given in Table III.

TABLE III. Showing the quantities of various foods consumed by an individual of *Blarina brevicauda* when a single article of food was furnished.

Article of food.	Number consumed.	Number of days on which this food was exclusively furnished.	Average diet per day.
Meadow voles	4	6	$\frac{2}{3}$
House mice	3	3	1
May beetles (adult)	77	5	15
May beetles (larvae)	26*	2	13
Earthworms (4 cm. when contracted)	142	4	35

Other articles of food were furnished at other times, and some proved favorites; but owing to the difficulty in securing the food no quantitative data were secured. Other insects, such as various ground beetles, giant water bugs (Benacus), and *Hydrophilus triangularis*, were furnished. All were eaten, but the ground beetles were the favorite. Other larvae of insects besides Lachnosterna were readily taken, even the "woolly bear" of *Pyrrharctia isabella*. Sowbugs were eagerly devoured. When live food was not to be had, beef was furnished, and was eaten readily. I made only two stomach examinations. One stomach contained an insect larva mutilated beyond recognition; the other the remains of a meadow vole, recognizable by the hairs swallowed with the flesh. Vegetable foods were invariably rejected, though Professor Reighard has captured the shrew in traps baited with nut meats scented with

* Proved insufficient; all were consumed by 11 A. M. on second day.

anise oil, and the specimens taken still had fragments of the nut meats in their teeth.

Method of Capturing Food.— On several occasions I witnessed the capture of prey. In the case of the voles and the mice, the attack was essentially the same as described by Merriam (1886, pp. 166-168) and Morden (1883, p. 283). The house mouse, being very agile, was not taken in the open, but only when it entered the shrew's burrows. I observed this twice. The clumsy vole, on the other hand, was pursued above ground, cornered in the cage, and caught. In each case the shrew seized the animal's ear in its teeth. After the shrew had been dragged around the cage until its victim was almost exhausted, it quickly loosed its hold on the ear, seized the head in the parietal region, and pierced the skull with its teeth. In two cases the prey was dragged part way into a burrow after it had been killed. In the third case it was eaten at once at the surface. The brain and cranium were eaten first, then the neck and shoulders. The skin was closely cleaned and rolled back till the tail was reached. The snout, legs, skin, and tail were left.

Some difficulty was experienced in making observations on the eating of snails. When beef or mice were furnished, snails were not touched. Finally, when all other foods were excluded, snails put in the cage of a morning were devoured before the following morning, though they remained untouched during the day. Learning by this means that the shrew would eat snails at that time of year (early in June), I starved it for a day, then in order to keep it at the surface put it into a cage with sandy soil, and gave it a few snails. The snails were large and their shells were hard. The shrew put its lower jaw into the aperture in an attempt to reach the snail. Once its forefoot was thrust in. Failing to get the snail in this way, it set its teeth across the outer turn of the shell and tried to break it. This it failed to do in my presence, but later the same shells were found broken. It seems from these observations that in the case of large shells, breaking is a last resort. A group of empty shells taken from one of the underground chambers in the series of burrows in which this same captive shrew was taken is shown in Fig. 5. The group on the left contains all the unbroken shells. Those on the right were broken,

being mostly small and immature shells of the same species as those on the left. These small shells were of course much more fragile than the mature ones.

From the way in which the attempt to get the snails was begun, it appears that when the shells are not broken the snails are dragged out through the aperture. I did not see this done. To determine whether it could be successfully accomplished, I seized an extended snail with a heavy forceps and pulled upon it strongly. With a steady pull the attachments to the shell slowly yielded and the snail was removed almost entire.

PSYCHOLOGY.

I have described reels which were set at several of the burrows to determine whether the animal that was moving the snails occupied the burrows. The same reels were used to determine how the occupied shells were distinguished from the empty ones. The possible means that suggested themselves were the weight of the snail, and the senses of touch, sight, and smell.

Muscular Sense.— To learn whether weight was the criterion, an empty shell was stuffed with sandy soil till it was about as heavy as an occupied one. This, with an empty shell and an occupied one, was placed near one of the burrows. Each shell was tied to a reel, and all were placed at equally accessible points. The occupied shell was drawn into the burrow at the time of the first decided rise of temperature, while the other two were left indefinitely. The experiment was repeated, but the occupied shell was so placed that the shrew would have to go round the empty and stuffed shells and under the reel in order to get it. The occupied shell was again removed and the other two left. The experiment was twice repeated at another burrow, with the same results. Evidently weight of shell is not the determining feature. It seemed possible that the center of gravity might not be at the same point in a stuffed shell as in an occupied one, and that the shrew could detect this difference. Therefore the position of the center of gravity in a stuffed and an occupied shell was determined by balancing on a knife edge and by suspension; it was found to be the same in the two shells.

Tactile Sense.— It might be supposed that the shrew would reach into a shell with its feet and feel whether the snail was there. I found later that the tactile sense was acute. When the shrew was running at full speed in its cage and came upon an obstacle, it invariably stopped short before touching it except with its vibrissae. The most common obstacle was its water dish, which was frequently moved about to different places in the cage. I am not certain that I ever observed the shrew run against the water dish even immediately after it had been moved. I have seen the shrew run past masses of such favorite food as earthworms without

FIG. 5.— The empty shells taken from a single underground storage chamber of *Blarina brevicauda*. The shells on the left were entire: those on the right broken, being mostly immature shells of the same species as those on the left.

noticing them, but when a worm in its wriggling touched the tactile hairs, the shrew turned at once and seized it. To learn whether the tactile sense was used to determine the presence of a snail in its shell, I stuffed the apertures of several occupied shells with soil firmly, so that the snails were out of sight and reach. The external appearance of one of these shells was to a human observer precisely like that of a stuffed one, unless it was held up to the light. Then the central turns of the unoccupied shell into which it was impossible to force the soil appeared lighter than in the shells containing snails. The shells with apertures closed with dirt were placed,

along with stuffed and empty shells, at several burrows. The occupied shells were again removed, to the exclusion of the others.

Sight.— Blarina has not been accredited with acute vision, the principal function of its eyes being, as Merriam (1886, p. 165) has supposed, to distinguish light from shadow. To determine this point at first hand, various tests were made on the shrew in the laboratory. Objects varying in size from a lead pencil to a book were waved before the shrew, first at a distance of a foot or more. No notice was taken of them. The distance was gradually shortened until the objects almost touched the shrew's vibrissae, but still the animal was not disturbed. Once when a cigar box was thrust violently toward the shrew, the latter shrank back and immediately turned to face the object. Thinking that the response might have been due to air currents, I moved various objects, as cards, boxes, or books, toward or past the shrew in an oblique position so as to produce currents. The shrew invariably noticed these although its head was sometimes turned away from the object. I then blew lightly upon the animal and it turned toward me and chattered vehemently. I have concluded that, in the above case where notice was taken of the cigar box, the response was due to air currents, and that the box had not been seen.

The above experiments were all performed with the cage between the moving objects and the window. When similar movements were made on the opposite side of the cage so as to throw a shadow over the shrew, the animal was at once disturbed. If a large object, as a book, were used to cast the shadow, the shrew frequently hurried into one of its burrows. Sight, then, can hardly serve to distinguish occupied from empty or stuffed snail shells in cases where a human observer could not discern a difference. The remaining possible means of distinguishing them is by their odor.

Smell.— When mice or beef were placed in the cage the shrew almost invariably came out of its burrows in a short time. It rarely did so when the lid was merely raised and lowered, or when other objects, as the water dish, were put in. In the case of the mouse, the response may have been due either to the trembling of the soil as the mouse ran about, or to the odor of the mouse; but with the beef, the disturbance of the ground was eliminated. When the shrew was above ground, it was always going about

with its nose slightly elevated and its nostrils dilating and contracting rapidly in unison with movements of the sides of the body, as if sniffing the air. It is further noted (Table I) that only 7 of the 25 snails killed in formalin were ever moved from their places at the burrows in the field. I have concluded from all these observations that the distinction between empty and occupied shells is due chiefly to the odor of the snail. Possibly weight is another factor, for although the experiments showed that weight was not effective apart from odor, no experiments were performed with odor apart from weight.

Hearing.— It has been pointed out by both Merriam (1886, p. 165) and Kennicott (1857, p. 95) that the hearing of the shrew is acute. This was not at once apparent from the shrew that had been for some time in confinement. It was oblivious to sounds that were often repeated. It took no notice of footsteps, and conversation did not disturb it. Even the slamming of the door did not at the last appear to be perceived, but slight sounds that I produced for the first time made the shrew start. Plucking a taut string within a foot of the shrew produced this result. A shrill whistle caused it to run into the corner of its cage, though I was careful not to blow upon it. It started violently when a strip of metal was drawn across the lip of a tin can near the cage. Each of these noises when repeated a number of times at various intervals ceased to produce any effect, even when several days had elapsed since last producing them. The flutter of wings of a pigeon kept in the same vivarium, on the other hand, always sent the shrew scurrying into its burrows. I observed this more than twenty times, at intervals throughout the five weeks of the shrew's captivity, and the last flutter produced as much disturbance as the first. This particular sound must have been heard hundreds of times during that period, yet even at the last could not be heard with equanimity by the shrew.

Effect of Light and Heat.— Sufficient evidence has been offered that most of the shrew's work on snails is done at night. Eight of eleven voles and mice put into the cage of the shrew were killed at night. Most of the food which was small enough was dragged into the burrows to be eaten. In my field work I twice saw a shrew come momentarily to the surface, once in March and once

in April. Both days were rather cool, though the sun was shining brightly. Still more conclusive, at least in regard to heat, was the behavior of the shrew when brought out to be photographed in a dish lined with white paper. The animal was exposed to direct sunlight when the temperature was about 30° C. It tried at every point to get under the paper lining of the dish, while its breathing rapidly increased. After some 8 minutes of exposure it was evidently overcome by heat, and after dancing wildly about a short time on all fours, lay motionless. Long continued bathing with cold water was necessary to restore it. It is evident that times of daylight and even ordinary summer heat are not selected by the shrew for its greatest activity. On the other hand, even if there were no direct evidence of daylight activity, the capture of shrews by hawks (Fisher, 1893) shows that the animals occasionally come out upon the surface by day.

SUMMARY OF PRINCIPAL RESULTS.

1. *Blarina brevicauda* preys upon various snails of the genus Polygyra, at least in winter.

2. These snails are hoarded, and are in general moved to the surface of the ground as the temperature falls and into the burrows as it rises.

3. Empty shells which are brought to the surface are not moved back into the burrows. The basis of distinction between empty and occupied shells is the odor of the snail, or possibly the odor combined with the weight.

4. Empty shells not left at the surface are stored about the nests, along the burrows, or in special chambers.

5. Other principal foods are voles, mice, insects, and earthworms. Vegetable foods, except nuts, are not employed.

6. The burrows of *Blarina brevicauda* are similar to those of *Microtus pennsylvanicus*, but may be distinguished by the following features:

a. The runs of Blarina, when underground, open to the surface at points more than 1 meter apart; those of Microtus have openings less than 1 meter apart. Burrows of Blarina often extend as deep as 40 cm. into the soil; those of Microtus rarely more than 15 cm.

b. The nests of Blarina are always underground; those of Microtus are more usually at the surface.

c. Blarina uses all its nesting materials unaltered; Microtus shreds or tears coarse material.

d. The excrement of Blarina is greenish black, coiled spindle-shaped, about 25 mm. long; that of Microtus is black or brown, spindle-shaped, 5 to 8 mm. long.

7. The smell, hearing, and tactile sense of Blarina are acute; its sight serves merely to distinguish light from shadow.

Discussion.

The short-tailed shrew is easily recognized. It differs from other shrews by its large size, having a total length of 120–124 mm., by its short tail (23 mm.), and relatively small feet (hind foot, 15 mm.). From the common mole and Brewer's mole, it is distinguished by its smaller size, and by the absence of digging forefeet; from the starnosed mole it is further separable by the absence of tentacles around the snout.

In the field, the work of Blarina is readily distinguishable from that of either the common or starnosed mole by the smaller burrows, and the absence of humps of earth which are so characteristically heaped up by both moles. A further distinction is the ridge of earth over the burrows of the moles, especially the common mole. Blarina does not make such a ridge, at least in soft ground.

It has been noted that the runs used by Blarina at the surface of the ground are precisely like those of Microtus but that the burrows as a whole differ in several respects. The most interesting of these differences concerns the material of which the nests are composed. Shredding or tearing it into pieces would perhaps make the nest more comfortable and the shrew is fully capable of thus altering its material. But the shrew is carnivorous and Microtus is a rodent. To the latter, with its gnawing incisors, accustomed to dividing and tearing roots of grasses and the bark of trees, the shredding of nesting material is a natural process.

The collecting of empty shells around the nest of the shrew seems significant in relation to the origin of the nesting habit. One nest which I have described was made entirely of the hair

of the vole, rejected parts of its food. Microtus nests are commonly made of the husks, leaves, and silk of the corn, or of the chaff and leaves of the wheat which it devours. It is easy to conceive that in this way the nesting habit of the shrews also originated. If this be true, the use of grass, leaves, and sedge, now so common among the shrews, must be a secondary modification, since these articles are not rejected food materials.

The fact that in the laboratory the shrew did not make any defined runs at the surface, suggests that it may not make any in the field. If this is true, the runs which it occupies were probably made by Microtus. They may have been entered in pursuit of game, and when the original owners were captured, their burrows were appropriated. The finding of broken snail shells in Microtus nests seems to support this view, since Microtus does not eat snails. The shells must have been carried thither on a foraging expedition, and devoured in the nest of the vole. To what extent the runs used by Blarina have been appropriated by it has not been determined.

Many of the shells found around the nests of Blarina, in underground chambers, and in the burrows, were shown by the numbers painted upon them to be those which were previously heaped at the surface. The snails, therefore, were being hoarded, and used gradually. Bachman (1837, p. 370) mentions that beetles are hoarded by shrews of the genus Sorex, and Merriam (1886, p. 169) thinks it probable that Blarina stores food. Dahl (1891) has found masses of earthworms, having their anterior segments injured, in the burrows of the European mole; but Adams (1903, p. 14) thinks they merely fell in and could not get out,— he does not explain the injury of the anterior segments. There is no mention of hoarding among shrews on as large a scale as this of the snails seems to be. It has been noted that the snails were carried out on top of the ground in considerable numbers when the temperature fell markedly, and were taken back in equally large numbers when there was a marked rise in temperature. The snails seem to be kept in the coldest place available. In cold weather this is above ground; in warm weather, in the burrows. Though the temperature in February and March never rose high enough to render the snails active, yet some of the snails at the burrows referred to in Table II were still at the surface

early in April when it was warm enough for them to crawl. This may have been due to the fact that my first shrew was captured at this set of burrows, so that only one shrew was left to devour the snails originally intended for two. Bodies of Microtus were hoarded but were not transferred to the surface. This again indicates that the cold storage serves to keep the snails immobile rather than to prevent decomposition.

Too little has heretofore been known of the short-tailed shrew to make an estimate of its economic importance practicable. Stomach examinations are almost wanting, my own work including but two. However, from data concerning the quantities of food in laboratory and field, I have attempted an estimate of the economic importance of Blarina.

Three principal elements determine the economic value of a species, namely its range, its abundance, and the character and quantity of its food. Of the range of Blarina, Rhoads says (1903, p. 192): "Atlantic Ocean to Nebraska and Manitoba; Quebec to Virginia." This is practically the northeastern quarter of the United States. Of its abundance, the same author says (p. 193): "This species stands preeminent above all others of our mammals in its combined abundance and universality of distribution in all conceivable situations. Not a place have I trapped over in the two states but what it was among the first species to be caught. It is found in our deepest, coldest mountain ravines, on the stormy, barren mountain top, in the banks and valleys of low tidewater streams and maritime marshes, and delights in roving from the cool sphagnum bogs of the N. J. cedar swamps where the temperature may be below 60° to the hot sand barrens of the adjoining fields with a mid-day heat of 110.° Forest and plain, sand and clay, barren or fruitful field, back woods or door yard, heat and cold, wet and dry, day and night, have common charms for this cosmopolite." It is difficult to conceive of the shrew in some of these situations after having observed its almost futile attempts to burrow in heavy, sandy soil that was not even compacted. Yet numerous records attest its presence in these situations.

Montgomery (1899, p. 572) has used the number of skulls of different mammals found in the pellets of owls to determine the relative abundance of the animals. Shrews necessarily came far

down the list, because few were captured; and he found that *Blarina parva* is more abundant than *B. brevicauda*. It seems to me that the small number captured is due to the fact that they are underground most of the time, rather than to their rarity. From my own observations, assuming that a pair was present at each nest that was being used, as I found to be the case in two instances, there were at least two pairs to the acre over the region studied. This number should be easily maintained for, according to Rhoads (1903, p. 195), they produce four to six young at a litter, and breed the year round.

The quantity of food eaten in a month has been estimated as follows: From Table III was computed the quantity of each item which would have been consumed in a month had that article alone been furnished. For example, one month's rations of voles alone would be 20; of house mice, 30; of adult May beetles, 450; and so on. It has already been stated that 130 snails were eaten by one shrew between Mar. 1 and Apr. 31. However, since the moving of the snails by the shrew had practically ceased by Apr. 7, it seems probable that the snails were eaten in a little over one month. Moreover such other foods as insects, earthworms, and voles were available at the same time, so that the snail diet was not the total. It seems reasonable to assume that 120 snails alone would make one month's rations, since that is more nearly the equivalent of 20 voles.

The distribution of the dietary among the different articles is largely a matter of judgment, and in Table IV the quantities are based on the relative abundance of the various items in the swamp region studied. For example, voles were abundant, and have been allowed to constitute 40% of the diet. Earthworms, on the other hand, were comparatively rare in the peat of the swamp, and have been allowed but 5%. The table of course represents only a sort of average for the year. Snails are evidently eaten in much greater numbers during several months of the winter, when the insect diet is necessarily limited. The snail diet is probably less in upland situations, though Charles A. Shull, of Kentucky University, tells me he has found the characteristic heaps of snail shells, all *Polygyra thyroides*, about the openings of small burrows in high land near Lexington, Ky. This was probably the work

of Blarina. In other situations than the peaty swamp, the earthworm diet is probably greater than I have estimated. In proportion as other foods not here included are employed, the quantities in the table will be diminished.

TABLE IV. Showing estimated quantities of various staple foods devoured by a single *Blarina brevicauda* in one month.

Article of Food.	Estimated number eaten.	Per cent. of total rations.
Meadow voles (or equivalent in mice)	8	40
Adult insects (of the size of Lachnosterna)	90	20
Insect larvae (of the size of Lachnosterna)	78	20
Earthworms (4 cm. long in contracted condition)	53	5
Snails	18	15

Estimating the number of shrews as I have done at four per acre, it appears that the number of meadow voles devoured by them on a farm of 100 acres in a year is $100 \times 4 \times 12 \times 8 = 38400$. Since this number can scarcely be supplied, the capacity of the shrews for keeping the voles in check is not strained. Where this quantity of voles can not be found, either other foods must be eaten in equivalent amounts, or the shrew is capable of subsisting on shorter rations, or the estimated four shrews per acre can not exist. Farmers should take note of the economic value of Blarina. In their zeal to rid their premises of noxious animals, they sometimes kill indiscriminately anything that looks like a mouse. One of these animals evidently kills many more voles in a year than the farmer himself. The shrew even compares favorably, from the economic standpoint, with the common owls. Montgomery (1899) examined the pellets of four long-eared owls for a period of two months, and found that these birds had devoured 347 small mammals, mostly Microtus. This is an average of 43 per month for each owl. Blarina devours 20 voles per month, or an equivalent in insects, most of which are even more destructive than the voles.

With abundance of food, it might be expected that the race of short-tailed shrews would become very numerous. But other forces are at work maintaining the balance of nature. The investigations of Fisher (1893) show that six species of hawk and six species of owl capture the short-tailed shrew. Two other species

of owl capture shrews but the species of shrew is not stated. Montgomery (1899) found the skulls of shrews in the pellets of the long-eared and the short-eared owl. The number of shrews taken, however, is relatively small. For example, Fisher (1893, p. 53) found in 562 stomachs of the red-tailed hawk 45 specimens of shrews. Of these one third were short-tailed shrews, taken in 10 individual stomachs. In 39 stomachs of the barn owl (p. 139) 5 specimens of shrews were found, among which was Blarina. Montgomery (1899, p. 566–567) found that out of 347 skulls of mammals taken from the pellets of the long-eared owl, only one belonged to Blarina. These figures show that the item of shrews does not count very heavily against the hawks and owls in estimating the economic value of these birds.

The subject of bird enemies of the shrew recalls the disturbance produced in the laboratory by the fluttering of the pigeon's wings. The sound was probably recognized as a familiar one by the shrew. This accounts for the fact that the animal never became oblivious to this particular sound.

Surface (1906, pp. 155, 160, 189, 197) has found shrews in the stomachs of four species of snake, though in small numbers. In at least one case he was able to identify the specimen as Blarina. Rhoads (1903) and Stone and Cram (1902) state that small mammals are captured by foxes, minks, weasels, and skunks. In several instances they mention shrews among the number, but in no case is specific mention made of *Blarina brevicauda*. Dickerson (1907, p. 356) records that three specimens of *Blarina brevicauda* were found dead in the fallen nest of a red squirrel. She believed them to have been killed and stored there by the whitefooted mouse. This mouse is well known to utilize deserted nests, among others that of the red squirrel, but whether it kills shrews is doubtful. It appears to me more probable that the shrews had been killed by larger beasts of prey and rejected, possibly on account of their odor (Rhoads, 1903, p. 193; Stone and Cram, 1902, p. 182), and had then been picked up by the whitefooted mouse. This mouse is said by Stone and Cram (1902, p. 132) to glean after other hunters.

From bird enemies the shrew can escape to its burrows. From those enemies that can pursue it in its burrows, some other means of

escape must be employed; perhaps it pushes out into the loose soil. The instance of the obliquely descending burrow at one nest suggests the "bolt run" by which the European mole is said to escape when its fortress is attacked (Adams, 1903, p. 13). This burrow, however, was probably not a back door escape, since it ended blindly and the shrew did not enter it at this time of attack.

The short-tailed shrew is so well protected from its enemies that no animals appear to depend upon it for food. It is abundant and widely distributed. In security it devours such quantities of voles and insects that its economic importance is considerable; and since, unlike the other common shrew, *Sorex personatus*, it is almost exclusively carnivorous, there is little to detract from its economic value.

UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

LITERATURE CITED

BACHMAN, J.
1837. *Journ. of the Acad. of Nat. Sci. of Philadelphia*. Vol. 7, pt. 2.

KENNICOTT, ROBT.
1857. The Quadrupeds of Illinois Injurious and Beneficial to the Farmer. *Rep. of the Commissioner of Patents* for 1857. Agriculture.

MORDEN, J.
1883. *Canadian Sportsman and Naturalist*. Vol. 3, p. 283.

MERRIAM, C. H.
1886. The Mammals of the Adirondack Region. Henry Holt. 316 pp.

DAHL, FR.
1891. Die Nahrungsvorräthe des Maulwurfs. *Zool. Anz.* Bd. 14, pp. 9–11.

FISHER, A. K.
1893. The Hawks and Owls of the United States in their Relation to Agriculture. *U. S. Dept. of Agric.*, Div. of Ornith. and Mammal., Bull. No. 3.

MONTGOMERY, T. H., JR.
1899. Observations on Owls with Particular Regard to their Feeding Habits. *Amer. Nat.* Vol. 33, pp. 563–572.

STONE, W., AND CRAM, W. E.
1902. American Animals. Doubleday, Page and Co. xxiii + 318 pp.
ADAMS, L. E.
1903. A Contribution to our Knowledge of the Mole (Talpa europæa). *Mem. and Proc. of the Manchester Lit. and Phil. Soc.* Vol. 47, No. 4.
RHOADS, S. N.
1903. Mammals of Pennsylvania and New Jersey. Philadelphia. Published privately. 266 pp.
SURFACE, H. A.
1906. The Serpents of Pennsylvania. *Pennsylvania State Dept. of Agric.*, Monthly Bull. of the Div. of Zool., vol. 4, nos. 4 and 5.
DICKERSON, MARY C.
1907. The Pageant of Nature. *Country Life in America*. Vol. 11, p. 356.

NOTES AND LITERATURE

GENERAL BIOLOGY

The Philosophical Problem of Life.— Dr. Verworn, Professor of Physiology at Göttingen, has recently published a lecture upon the investigation of life, delivered before the society of political science at Berlin.[1] At the outset he states that the search for a cause in biology is unfruitful and unscientific. "There is no process in the world which is determined by a single cause. Every process is always dependent upon a number of other processes and it is unjustifiably arbitrary to select one of these and to account it the first cause.... A scientific investigator can only establish the several conditions which are necessary for the occurrence of a process. If these are known, the process is accounted for,— explained. The process is nothing more than the expression of the sum of the concomitant conditions. The conception of cause becomes therefore superfluous and worthless."

Accordingly one must regard as superficial such affirmations as that an insect is colored green because it is thereby protected, or that a mammalian embryo has gill clefts because its ancestors did.

From the study of the conditions of life Professor Verworn concludes that,— "To produce life artificially we must know completely *all* the elements of the living substance. We must know the relative amounts. We must understand their arrangement in the cell body. If we could construct such a system, fulfilling all the conditions of life, the artificial cell would at once live. It would certainly be extremely interesting to see how the artificial organism would live, reproduce, and transmit its qualities — but the prospect of producing life is a complete Utopia. We have not learned to approach the complex conditions involved in a living organism....The chemical fabric of a cell should first be so understood that it could be imagined as a great machine shop, in which the mechanism of life could be observed by wandering among the atoms as among wheels and cylinders."

Consciousness also is held to be a product of these conditions. If, according to DuBois-Reymond, we could bring together at once and in their proper relations all the atoms of which Cæsar was composed

[1] Verworn, M. *Die Erforschung des Lebens.* Gustav Fischer, Jena, 1907. 45 pp. 1 Mk. 80 Pf.

when he crossed the Rubicon, we should have reconstructed Cæsar, body and soul. The artificial Cæsar would have the same sensations, aspirations, and ideas as his predecessor at the Rubicon. Both consciousness and life, therefore, are the expression of definite *conditions* to determine which is the object of scientific investigation.

Professor Verworn here ascribes as a cause of consciousness an unknown arrangement of atoms. A more conservative opinion has been expressed by an American biologist, as follows,[1] — "The work of physiologists has been so devoted to the physical and chemical phenomena of life that the conviction is widespread that all vital phenomena are capable of a physical explanation. . . . Let us give up the ineffectual struggle to discover the essential nature of consciousness until we can renew it with much larger resources of knowledge."

In regarding the construction of a living cell as a complete Utopia, Professor Verworn differs from Professors Le Dantec and Cresson. The former writes,[2] — "Our knowledge of colloids is still so recent and rudimentary, that we ought not to expect to see the making of a cell accomplished soon; but it will come some day by careful analysis, permitting a rational synthesis. . . . The scientific world today is so prepared for the discovery that the premature announcement of spontaneous generation in gelatine submitted to the action of radium surprised no one. . . . It is not necessary for an enlightened mind to see protoplasm made to be convinced of the absence of any essential difference,— any real discontinuity, between living and dead matter."

Professor Cresson,[3] after quoting Büchner that "doubtless some day it will be possible to form living protoplasm artificially," adds,— "Such a hope is at least somewhat reasonable and probable." When, however, it is considered that nowhere in nature are such conditions known to be realized at present, and that the conditions in the past when life arose are equally unknown, one is inclined to accept Professor Verworn's characterization,— a complete Utopia.

It is unnecessary to refer further to Dr. Le Dantec's volume, which was published some months ago in English, and has been frequently reviewed. Dr. Cresson's more recent volume is a simple introduction to naturalistic philosophy. The author describes the development

[1] Minot, C. S. The problem of consciousness in its biological aspects. *Science*, N. S. vol. 16, 1902. pp. 1–12.

[2] Le Dantec, Félix. *Éléments de philosophie biologique.* Félix Alcan, Paris, 1907. 297 pp. 3 fr. 50.

[3] Cresson, André. *Les bases de la philosophie naturaliste.* Félix Alcan, Paris, 1907. 179 pp. 2 fr. 50.

of natural science and its conflict with the "old geocentric and anthropocentric philosophy which seduced and satisfied our ancestors.... Science has descended upon this philosophy like a tempest and nothing is left. The earth is not the center of creation. Man is not an exception in the universe. The adaptation between living things and their environment is explained by evolutionary principles without supposing an intelligent creator." In the preface, philosophy is said to be a matter of temperament. "For some, naturalism is the final word of true metaphysics; for others, it is devoid of all truth." In this way, perhaps, the author acknowledges, that there are many who see in evolutionary principles the manifestation of an intelligent creator; and who find in man, though one animal among many, much that is exceptional. It is stated by Professor Cresson that naturalistic philosophy is not science, though suggested by it. The determination of the conditions of life, as described by Verworn, is science itself.

F. T. L.

The Capitalization of Specific Names.— It is agreed that the name of a genus shall always begin with a capital letter and that the specific name shall usually begin with a small letter. Zoologists are inclined to begin specific names invariably with small letters, but botanists employ capitals for a variety of purposes as shown in the following examples:

	Zoological Names.	Botanical Names.
a.	*Sitta canadensis*	*Juncus Canadensis*
b.	*Lampetra wilderi*	*Smilax Walteri*
c.	*Gastropacha ilicifolia*	*Lythrum Hyssopifolia*
d.	*Bernornis isabellae*	*Rosa Beatricis*

Whatever reasons exist for beginning these botanical names with capitals apply with equal force to the zoological names; and the advantages of the invariable rule for lower case letters are no greater in zoology than in botany. Moreover, as expressed by the Vienna Congress of botanists,— "The principles and forms of nomenclature should be as similar as possible in botany and in zoology." In the matter of capitalization of specific names, one rule should apply to both. In order to determine upon a uniform practice for the *Naturalist* (in which botanical and zoological names should appear with equal frequency) the editor examined the following codes.

1842. A committee of the British Association, appointed "to consider of the rules by which the Nomenclature of Zoology may be established on a uniform and permanent basis," presented various

"Recommendations for improving the nomenclature in future." Among these is § C. "Specific names should *always* be written with a small initial letter, even when derived from persons or places, and generic names should always be written with a capital."

1865. The British Association code was revised, and although the rule for small letters had been very generally adopted, the section relating to it was omitted. The revised code stated that "It is not a matter of great importance and may be safely left to naturalists to deal with as they see fit."

1881. The Société Zoologique de France stated,—"Every one agrees that the name of the genus should be written first and begin with a capital letter. For the specific names, there is also unanimity if they are common nouns or adjectives,—a small letter is used. Should proper nouns and adjectives be treated in the same way? Some persons adopt and recommend the practice. Your committee considers that the question is of very minor importance. It believes that it conforms to the most generally established usage in recommending the capital, which is not inconvenient, and may in fact, in certain cases, be a useful distinctive mark."

1881. The rules of the International Geological Congress at Boulogne, in regard to the nomenclature of species, merely state that "the rules of Latin orthography are to be followed."

1886. In the code of nomenclature adopted by the American Ornithologists' Union, Canon VIII states that "proper names of species, and of subspecies or 'varieties,' are single words, simple or compound, ... written with a small initial letter."

1893. The Deutsche Zoologische Gesellschaft adopted a code containing the following note to § 10. "It is very desirable to write not merely all adjective but also all substantive specific names invariably with small letters."

1904. A committee of the International Zoological Congress framed a code containing Art. 13.—"While specific and substantive names derived from names of persons may be written with a capital initial letter, all other specific names are to be written with a small initial letter."

1905. At Vienna the International Botanical Congress adopted the following *recommendation*. Chap. III., Sect. 4. Recommendations. X. "Specific names begin with a small letter except those taken from names of persons (substantives or adjectives) or those which are taken from generic names (substantives or adjectives)."

1907. The nomenclature commission of the Botanical Club of the

American Association for the Advancement of Sciences rejected various fundamental principles of the Vienna code and framed an 'American code'. Part 3, § 1, art. 3 reads,— "If capital letters are to be used for specific names they should be employed only for substantives and for adjectives derived from personal names." This is followed by the curious example *Uromyces Trifolii*, and in another place the specific name *Tulipifera* is capitalized.

The examination of these codes shows that the most radical rule was that of the British Association in 1842, and that this was subsequently cancelled. Nevertheless the progress toward its adoption seems constant. The botanists have ruled against capitals for nouns and adjectives denoting places (example *a* in the list). Since a very large number of botanical names are of this sort, the progress toward decapitalization is considerable. Capitals for personal names are recommended by the botanists, small letters by the German zoologists and American ornithologists, and both forms are sanctioned by the international code of the zoologists. The botanists are alone in recommending capitals for specific names derived from those of genera (example *c*). Under this rule a person unfamiliar with the genera of plants must refer to an authoritative botany to ascertain the capitalization,— thus a zoologist would not expect to find *Datura Stramonium* and *D. Tatula* capitalized. Should a botanist desire to refer to a zoological species, however, a check list need not be consulted regarding the capitalization. Since no single practice can conform with all the codes and yet a uniform rule is obviously desirable, the *Naturalist* will capitalize specific names only at the request of a contributor; the invariable use of small letters is recommended. It is to be noted that the Vienna code allows choice in this matter. Chapter I, Art. 3, states that "the rules of nomenclature should be neither arbitrary nor imposed by authority,— they must be simple and founded on considerations clear and forcible enough for every one to comprehend and be disposed to accept." [1]

[1] Since this was written the University of Missouri has issued *The Flora of Columbia Missouri*. The specific names derived from places are capitalized contrary to the Vienna code. The confusing nature of the capitalization is apparent from the following examples,— *Leonurus Cardiaca*, *Apocynum hypericifolium*, *Robinia Pseudacacia*, *Vernonia pseudobaldwinii*. The corrigenda include,— for *Achillea millefolium*, read *A. Millefolium*. *Potentilla Norvegica* of the text is indexed as *P. norvegica*. In Dr. Cockerell's *Bees of Boulder County, Colorado*, also just received, all specific names of plants visited by the bees are written with small letters, e. g. (p. 243) *Linum lewisii*. This is the practice which the *Naturalist* adopts.

The opinions of the botanists who are associate editors of the *Naturalist*, upon the capitalization question are as follows:

a. "I shall be very glad to follow the practice of lower case spelling for specific names in conformity with zoological usage."

b. "I am not very positive in my opinions of right and wrong on the capitalization question. I am going to try to follow the Vienna practice as consistently as possible. The zoological decapitalization has some valid arguments against it. In its favor is the fact that no knowledge is required on the part of those who adopt it, other than that the specific name chosen is to be used. I should suppose that for the *Naturalist* a uniform practice for the different departments of biology would be adopted, and the line of least resistance would be uniform decapitalization. Any proof-reader is then competent to correct all deviations."

c. "I have no decided opinion on the subject. My instinct is to use capitals for adjectives derived from proper nouns, as it somehow does not look right to me to see them spelled with small letters. I have no objection to offer if it seems best to adopt the uniform rule of small letters for specific names."

d. "Botanists should follow the international code. Personally I come near it, that is, I write names derived from persons with capitals, e. g., *Goldoni Lewisi*, and names derived from other proper nouns with small letters, e. g., *Goldoni pennsylvanica*. American scientific men (some of them) seem never satisfied to do things in nomenclature the way the rest of the world does. Really we ought to write *G. Lewisi*, and *G. Pennsylvanica* following the genius of the Latin language."

In order to know whether Latin usage had any bearing upon the question at issue, the last sentence in this quotation was referred to Dr. A. A. Howard, Professor of Latin at Harvard College, who wrote, — "There are no ancient rules whatever for the use of capital letters in Classical Latin. Our earliest manuscripts are written throughout in capitals, and so are all inscriptions. When the minuscule letters were introduced, the capitals were sometimes, but not always, used to begin a sentence or paragraph, apparently only as a sort of embellishment. Proper names are written in small letters down to the time of the introduction of printing. Therefore it is absurd to talk about the genius of the Latin language in this connection. All rules for capitalization are of modern origin, necessitated by the invention of printing. It is customary for each country to follow, in writing Latin, the rules governing the language of the country, though German writers not infrequently begin Latin sentences with small letters."

e. "The question of capitalization of specific names has given me much concern, and I should be very glad were it possible to reach some practice which would be acceptable to *all* zoologists and botanists. At the present moment no less than three rules are in use by botanists. Personally I see no good reason for capitalizing any specific names and my preference is decidedly in favor of following the practice of the zoologists. Some botanists consistently adhere to the rule of *no* capitals and they are right. In adopting this rule, you would make the *Naturalist* the exponent of a uniform practice for all biologists, and would, I feel sure, gain the support of many botanists."

F. T. L.

ANTHROPOLOGY

Handbook of American Indians North of Mexico.[1]— The volume at hand is the first of the two parts of a most important and generally useful work, dealing with the North American Indian and prepared under the auspices of the Bureau of American Ethnology. The work is an encyclopedia of the Indian, dealing in alphabetical order, with every phase of his life as well as with his anatomical, physiological, and indirectly also with his mental characteristics. Preparations for this publication have been carried on since 1873, and since 1902 the task has been in the hands of a special editor. The second volume will probably appear in the course of the coming winter.

The work is the result of contributions of forty-six authors, specialists in various branches of anthropology throughout this country. Every article in it has not only been carefully supervised by the able official editor of the book, Mr. Hodge, but has also been sent for reading and suggestions to all the contributors. Moreover, there were held at the Bureau of American Ethnology, under the chairmanship of Professor W. H. Holmes, for many months, regular meetings three times a week, to which all the authors were invited, and where all the more important papers were read and freely discussed. The result, great credit for which is due to Professor Holmes, the Chief of

[1] Hodge, Frederick W., *editor*. Handbook of American Indians north of Mexico. Part 1. *Bur. of Amer. Ethn.*, bull. 30, Washington, 1907. 972 pp., with a map and numerous illustrations.

the Bureau of Ethnology, besides to the editor, is a compilation of brief but comprehensive, simply worded and well illustrated, authoritative articles, which represent the substance of our actual knowledge of the Indian. A further perfection and possibly extension of the subject matter will be attended to in future editions.

The work will prove in general a satisfactory reference book on the North American aborigines, and a valuable handbook on the subject in higher schools and colleges. It has, with its other merits, the distinction of being the first work of its nature in existence. The bibliography, though mostly restricted to synonymy, according to the original plans of the work, is nevertheless ample and will facilitate the researches of special students.

Among the authors contributing to this work are Miss Fletcher, Chamberlain, Fewkes, Kroeber, Gatschet, Cyrus, Thomas, Hewett, Boas, Cushing, Colville, Hodge, Hrdlicka, Hough, Dorsey, Mason, McGuire, Mooney, Swanton, Dixon, Culin, Matthews, Hewitt, Grinnell, Henshaw and others.

Among the individual articles may be mentioned Abnaki, Acoma, Adoption, Adornment, Agency System, Agriculture, Anatomy, Antiquity, Architecture, Arrows, Bows & Quivers, Art, Atlantis, Axes, etc.

The first volume embraces the letters A to M inclusive.

A. Hrdlička.

Games of the North American Indians. — In a large volume[1] Stewart Culin presents "a classified and illustrated list of practically all the American Indian gaming implements in American and European museums, together with a more or less exhaustive summary of the entire literature of the subject." The many amusements of Indian children, such as "tag," which are played without implements are not within the scope of his compilation, and dolls are not included. None of the games described as Indian were imported into America; on the other hand "we have taken their lacrosse in the north, and racket in the south, and the Mexicans on the Rio Grande play all the old Indian games under Spanish names." Certain games, however, strikingly resemble those of the Europeans, and with various modifications the same game is played throughout the continent, by tribes belonging to unrelated linguistic stocks.

[1] Culin, Stewart. Games of the North American Indians. *Bur. of Amer. Ethn.*, 24th Ann. Rep., Washington, 1907. pp. 1–846, 1112 figs., 21 pls.

Games of chance are described first. Dice in the form of banded sticks, plum stones, small bones, or ivory figures of birds or mammals (which count for the player whom they face after being thrown) were widely used. A second class of games of chance includes those in which a small stone or other object is hidden in moccasins or under wooden cups, suggesting the illicit "shell game." Forfeits ranged from arrows to horses, and the games were sometimes played far into the night.

Games of skill include archery, various ball games in some of which racing is involved, and the game of sliding darts along the hard ground or ice toward a mark. Like the dice game, *hoop and pole* with many variations was played throughout the continent north of Mexico. A hoop twined with a network like a spider's web was rolled along the ground and darts were thrown at it, the count being determined by the hole penetrated. It was played by men only, but the lighter game of *ring and pin* was played also by women and girls. A perforated or penetrable object, such as a rodent's skull, attached to a cord was swung in the air and caught upon a pin or dart fastened to the other end of the cord. The most elaborate of the games of skill is that which resembles lacrosse. It was sometimes played between the young men of different villages, there being thirty or more players on a side. Among the many training regulations there is one which forbids the eating of hares since they are timid creatures. Ceremonial dances precede the game; each side has its conjurer and the spectators are numerous. The players are dressed only in girdles and ornamental tails of hair or feathers. They are armed only with rackets but in the scrimmages of the game bones are occasionally broken.

"Games of pure skill and calculation such as chess are entirely absent." The minor amusements, briefly described in this volume, include whip tops, cat's cradles, bull roarers, swings, stilts, and others. The author concludes that the games are "instruments of rites or have descended from ceremonial observances of a religious character." The myths with which they are associated are as widespread as the corresponding games, which are not only for amusement but to drive away sickness and avert evil. The book is admirably arranged for reference. With the picture of each implement there is generally a vivid account of its use by an eye-witness. The author has written only the necessary introductory passages and summarizes the conclusions of his eight hundred pages in eighteen lines.

F. T. L.

ZOOLOGY

Oogenesis in Insects.—It is a much debated question whether the sex or germ cells are set apart at the outset of embryonic development or arise later by modification of certain of the somatic or body cells. The continuation of Marshall's studies on the anatomy and embryology of the wasp *Polistes pallipes*[1] treats of the early history of the cellular elements of the ovary. The author finds that in the embryos and very early larvæ, each undifferentiated ovary is a syncytium with a number of nuclei similar in structure. In the course of development oocytes, primitive nurse-cells, and follicular epithelial cells are developed from the undifferentiated cells of the distal end of the egg tube. In a similar study of a Phryganid[2] he found that the first differentiation had taken place in a fairly old larva. At this stage the cells may be either "1st, undifferentiated or, 2d, passing through the first stages in the development which is to result in the further differentiation of oocytes or nurse-cells. Cells of the first group may either remain unchanged and become the epithelial cells or they may pass through the same stages as those of group two." Thus Marshall believes that the sex cells arise late and have a common origin with certain other cells in the ovary.

These results agree essentially with those of the earlier workers, notably Korschelt, '86, on the history of the germ cells of insects, but are in sharp contrast to the results of Heymons '95, Lecaillon '00–01, and many other recent workers who contend that the germ cells are in origin perfectly distinct from the follicular epithelium.

W. A. RILEY.

Parthenogenesis of Bacillus rossii.—The theory that each body cell contained both male and female constituents, and that the egg cell in becoming mature gave off its male elements in the second polar body has also been much discussed. This idea was supported by finding that the second polar body was not given off from certain eggs which

[1] Marshall, Wm. S. '07. Contributions towards the embryology and anatomy of *Polistes pallipes*. II. The early history of the cellular elements of the ovary. Zeitschr. wiss. Zool. lxxxv; pp. 173–213, pls. 12–14.

[2] The early history of the cellular elements of the ovary of a Phryganid, Platyphylax designatus Walk. l. c. pp. 214–237, pls. 15–16.

developed parthenogenetically. According to Baehr,[1] the walking stick *Bacillus rossii* must be added to the list of parthenogenetic species in the development of which the second polar body is formed, and the first divides in two. There is no evidence of their functioning further for they apparently degenerate and disappear.

Contrary to a generally accepted belief that parthenogenesis in this species quickly leads to degeneration, the author reared perfectly healthy females from at least the ninth parthenogenetic generation. Apparently only females are produced,— it is a case of normal thelytoky.

W. A. R.

Phagocytosis.— By means of a clever technique Mercier[2] has been able to throw new light upon the much debated question as to the nature of the phagocytes in the batrachians and the insects. On injecting sterilized, powdered carmine before the beginning of metamorphosis he found that it was taken up by the leucocytes and that leucocytes thus marked were yet capable of phagocytosis. Through this method he was able to demonstrate beyond a doubt the active participation of the leucocytes in the degeneration of the muscle fibers. In the case of the batrachians the muscles exhibited signs of degeneration at the time that the leucocytes entered but in the case of the fly Calliphora such signs were not to be detected microscopically. The fiber becomes broken up into sarcolytes which are engulfed by the phagocytes. There is no such phenomenon as the formation of myoclasts and consequent autophagocytosis. The author was able to demonstrate with equal clearness the active participation of the leucocytes in the destruction of the fat body of Calliphora and to distinguish them from the so-called "pseudonuclei" of Berlese.

W. A. R.

Histolysis in Queen Ants.— Janet[3] has studied in queen ants, the degeneration of the wing muscles, which begins very soon after the

[1] Baehr, W. B. v. '07. Uber die Zahl der Richtungskörper in parthenogenetisch sich entwickelnden Eiern von Bacillus rossii. Zool. Jahrb. Anat. xxiv pp. 174–192. Pl. 16.

[2] Mercier, L. '06. Les processus phagocytaires pendant la metamorphose des batraciens anoures et des insectes. Arch. Zool. exp. et gen., 4e ser., t. v. pp. 1–151, pls. 1–4.

[3] Janet, Ch. Histolyse, sans phagocytose, des muscles vibrateurs du vol, chez les reines des Fourmis. C. R. Acad. Sci. Paris. cxliv, 1907, pp. 393–196.

nuptial flight. This histolysis does not begin simultaneously or advance with equal rapidity in all of these muscles and hence among fasicles apparently intact may be found those in which the degeneration is in various degrees of completeness or even terminated. Janet states that throughout the process there is no phagocytosis, or ingesting of solid particles by leucocytes. The wing muscles are finally completely replaced by adipocytes which, he believes, arise from leucocytes.

W. A. R.

Notes on Entomological Literature.— *The Green Pigment of Locustidæ.*— Podiapolsky [1] has studied both the chemical and the spectroscopic peculiarities of the green pigment extracted from the wings of *Locusta viridissima.* He was able to separate a yellow and a green pigment completely parallel to, if not identical with, the xanthophyll and the chlorophyllan of plant-green. The paper is very suggestive as regards methods.

W. A. R.

Inner Metamorphosis of the Trichoptera.— Much as the caddis flies have been studied from the biological and the systematic view point, comparatively little is known regarding their histologic structure, and practically nothing concerning their inner metamorphosis. Lubben's extended contribution [2] is therefore especially welcome. The author discusses the changes in the respiratory system, the sexual organs, and the alimentary canal. The work has not been limited to a single species but treats of a wide series and brings together many interesting details.

W. A. R.

Starving out the Codling Moth.— Under this caption Fabian Garcia of the New Mexico Agricultural Experiment Station issues a call to fruit growers to exterminate the codling moth in a single season! The late frosts of last April left little pome fruit in the territory: if fruit growers will but cooperate in the destruction of what little remains (which will all be worthless anyway because all will be wormy) and will destroy also all wild rosaceous fruit and walnuts, the codling moth, being deprived of its food, will be eradicated. The optimism

[1] Podiapolsky, P. '07. Uber das grüne Pigment bei Locustiden. Zool. Anz. xxxi pp. 362–366.

[2] Lubben, H. '07. Uber die innere Metamorphose der Trichopteren. Zool. Jahrb. Anat. xxiv, pp. 71–128, pls. 11–13.

of the plan, its faith in the applicability of laboratory results by the public, undaunted by the contemplation of the inertia of the human species, is delightful.

J. G. N.

Fossil Insects.— The four parts of Handlirsch's *Die Fossile Insecten* [1] now at hand (640 pages and 36 double plates) suffice to show that this is a work of first importance to every student of fossil insects. In bringing together and making accessible descriptions and figures of practically all the known fossils (at least, in the older strata, thus far treated), and in correlating the fragmentary knowledge of them with keen morphological insight, the author is rendering good service. Though not all his more radical changes in groupings are likely to prove acceptable, and though the multiplicity of new groups of all grades will seem at first confusing, all will agree that the collective result of the work is substantial progress. Hitherto few monographers of insect orders have noticed the fossil representatives of the orders. There will be less excuse for the neglect of the paleontological evidence in the future.

J. G. N.

A Catalogue that is in part a Monograph.— The sons of the late Baron de Selys Longschamps of Liege are building a worthy monument to the memory of their father in the issuance of a catalogue of his zoological collections. The first number that comes to hand (Fascicle xvii, Cordulines, by M. R. Martin) shows that this, for the Odonata at least, is to be a great monograph. This small subfamily of dragonflies containing fewer than 140 species, is described on 94 quarto pages, illustrated by 99 (mostly multiple) text figures and three colored plates. The text figures are admirably executed and are sufficient for all practical purposes. The colored plates add little of real value, although they greatly increase the cost of the work. To every special student of the dragon-flies, this work will be indispensable because of its comprehensive character and its general excellence.

J. G. N.

[1] Handlirsch, A. Die Fossile Insekten, und die Phylogenie der rezenten Formen. Leipzig. Wilh. Engelmann.

Berlese's Entomology.— Fascicles 21–22 (pp. 585–648) of Berlese's magnificent work [1] are just at hand. They conclude the discussion of the nervous system and begin that of the organs of special sense. Like the preceding fascicles these are not mere compilations but are rich in new facts for the student of insect morphology.

W. A. R.

BOTANY

The Fungi of Termite Nests.— We are accustomed to think of Belt's classic observations on the leaf cutting ants of South America as the beginning of our knowledge of the relationships between ants and fungi, but Petch [2] assures us that Sweathman in 1781, nearly a century before Belt's discoveries, stated that in tropical Africa some species of termites had chambers in their nests in which grew a kind of fungus used by the ants as food. Although the "fungus gardens" of the true ants of tropical America have been quite fully described, we have had until the present time no comprehensive treatment of the similar habits in the termites of the Eastern Hemisphere. Petch brings together and tests by his own extensive studies of the Ceylonese species, the scattered observations on this subject.

Ceylon does not afford such variety of form and size of termites as Australia and Africa, but the nests of *Termes redmanni* and *T. obscuriceps*, the only two species which Petch studied, are abundant everywhere except in the highest districts. The ant hills, roughly conical in form, are only about six feet high. Their upper portion is continued into one or more hollow conical structures called chimneys. The form of the nests varies greatly; they may slope gradually to the top of the chimneys, they may branch into several chimneys or they may have a solid apex and bear the chimneys at the side. They are built of earth and grains of sand brought up from the interior of the nest and cemented together by a secretion of the termites. A large portion of every nest is underground. In the early stages of development the presence of a nest is usually indicated by three or four chim-

[1] Berlese, A. Gli insetti, loro organizzazione, sviluppo, abitudini e rapporte coll, uomo. vol. 1. Milan. Societá Editrice Libraria.

[2] Petch, T. The Fungi of Certain Termite Nests. *Ann. Roy. Bot. Gard. Peradeniya*, 3: 185–270, pl. 5–21. 1906.

neys 10 –20 cm. high, surrounded by the scattered earth brought up in excavating the underground chambers. In fact in some cases the nest is entirely under ground and the chimneys are wanting. Reasons for the differences have not been found.

Internally the nest is composed of numerous chambers roughly oval in shape, 5–25 cm. in diameter and 5–15 cm. in height, connected by numerous galleries sometimes as much as 1 cm. in diameter but generally only large enough to permit of the passage of two or three insects at once. Similar galleries connect the chambers with the chimney. For a discussion of the purposes of this structure the original paper must be consulted. Some idea of the extent of the underground system of these nests may be gained from experiments which Petch made; in one case water was run in for two hours from a pipe delivering 15 gallons per minute but this was quite fruitless so far as filling the opening was concerned.

The chambers, except the royal cell, are generally nearly filled with a structure designated as the comb. This is a grayish or brownish mass, traversed in all directions by a labyrinth of anastomosing galleries, and closely resembling in general appearance a coarse bath sponge. The combs lie free in the chambers, leaving a clear space of 2 to 3 cm. between them and the roof and the sides. The comb substance is built up of closely packed balls of about 0.75 mm. in diameter, composed of finely divided vegetable substance. Under the microscope irregular pieces of ringed and pitted vessels, up to 250 microns in length, may be seen, as well as tracheids, sclerenchymatous cells, and the hyphae and spores of Halminthosporium, Diplodia, etc., all imbedded in a ground substance from which all structural detail has disappeared. The fact that the same substance is found in the intestines of the workers and soldiers, taken in connection with the regularity of formation of the comb from the small pellets, shows that this is made up of the excreta of the termites. It will thus be seen that the comb itself is not of fungus origin.

The surface of the comb is given a grayish or glaucous appearance by the presence of a thickly woven mat of fungus hyphæ. From this mass of hyphæ small stalked spheres arise by the combination of several threads into an upright stalk; these hyphæ branch repeatedly above and finally give rise to conidia. These are the "conidial formations" which have been described by all students of the fungi of termite nests. Injured spheres or stalks from which the conidia have fallen are never found on the comb, and it would seem that the termites in eating them must consume them at a single bite.

Some have suggested that this fungus is one which is found in the neighborhood of the nests on decaying wood and that it is introduced into the nest accidentally by the termites, but in an extensive investigation of the fungi of Ceylon in which large quantities of dead wood passed through his hands, Petch was never able to find any form at all similar to that in the nests.

Occasionally an agaric also develops from the comb. This species is the chief edible form of Ceylon and so generally is it esteemed that it is difficult to obtain perfect specimens, for the natives who collect them for food do not secure the long stipe intact and unfortunately they do not overlook many examples. This fungus has never been found growing from the hill itself but is always produced from the underground portions of the nest. The comb from which it develops may be as much as four feet underground but the most of Petch's specimens were found to grow from combs nearer the surface. The connection of the agaric with the hyphæ described above has not been demonstrated. Efforts to germinate the spores or to grow the sphere-producing mycelium from the tissue of the agaric have proven unsuccessful. It is not improbable, however, that they are stages of the same species. At first the agaric forms brownish-white, somewhat conical, tomentose columns 3 to 5 mm. in diameter and 1 to 2 cm. in height; in some cases Petch found as many as fifty of these on a single comb. All the developing agarics reach this stage but only one forms a Pluteus; the others cease growth before they reach the roof of the chamber and it has been found impossible to cause them to develop farther by experimental methods. This peculiarity of the species renders it almost impossible to obtain other than the mature and the very earliest stages. It has not been found possible to cause a normal comb to produce the agaric by artificial treatment, and after it has borne one, another will not be produced. No results have ever been obtained by digging in the nests at random in search of the intermediate stages; when the mature fruiting body has appeared on the surface no more may be expected from the same comb and it does not indicate that the other combs of the same nest are in a state in which they may be expected to produce agarics. The termites have been known to consume the stipe up to the surface of the ground and then to stop the opening. This agaric has been assigned to several genera, Lentinus, Collybia, Pluteus, Pholiota, and Flammula; Petch considers it a modified Volvaria. It has never been found when it could not be traced to the termite nests.

A second agaric seems sometimes to develop from the termite comb,

but probably only in wet weather. In this species a number of stipes may develop from the same comb.

If a piece of fresh comb be removed from the nest and placed under a bell jar the spheres will decay if the insects have been removed but both spheres and external hyphæ will be eaten if the termites remain. In the course of two or three days after the surface of the comb has been freed from these, small groups of erect hyphæ, indistinguishable from those which give rise to the agaric, but apparently derived from the interior of the comb-substance, appear and grow rapidly into tall thin structures resembling the conidial forms of Xylaria. Petch has carried on a large series of cultural experiments with this form and concludes that it is probably *X. nigripes*. The termites eat this too as it develops. After continued rain *X. nigripes* grows from deserted nests.

Besides these forms, Mucor, Thamnidium, Cephalosporium, and Peziza sometimes grow on combs removed from the nests. Since none of these are found in the nests, though some of them are capable of growing underground, it seems probable that the insects "weed out" undesirable fungi as they develop.

Although it is known that the termites will eat the fungi it is not definitely proved that they form the food of the insects. The two species studied prefer fungi, or wood which has been attacked by fungi. Whether a difference in food is a factor in the differentiation of the termites into workers, soldiers and sexed insects is not decided.

The author observes that the mycelium of *Entoloma microcarpum* is composed of spheres of swollen cells which in detail resemble the termite spheres but are not so highly developed. He thinks that the spheres of the termite nests and the "Kohlrabihäufchen" of the leaf-cutting ants investigated by Möller are parts of a normal mycelium and that their form has been little, if at all, modified by the insects.

J. Arthur Harris.

The Longleaf Pine.— Schwarz's *The Longleaf Pine*[1] is an attractive little volume, describing in a popular style the silvics of *Pinus palustris*, the valuable hard pine of the Southern States. The subject matter is considered under nine main headings which cover the character of the virgin forests of this tree and their natural rotation, the tolerance of the species, its relation to injuries by fire, insects, cattle, and swine, its rate of growth, and its technical forest management.

[1] Schwarz, G. Frederick. The Longleaf Pine in Virgin Forest, a Silvical Study. New York, John Wiley & Sons, 1907. 12mo, xii + 135 pp., illustr.

The longleaf pine is characteristic of the so called Southern Pine Forest, and occurs principally in a belt some 125 miles broad, from Virginia south and west along the coast to within a short distance of the Mississippi River, and in southeastern Texas. The chief type is that of a pure forest. Owing to various destructive causes, these forests are largely in groups of different ages. A second, mixed type is found farther inland, and is largely determined by differences in the composition of the soil. Here the longleaf pines occur on the hilltops while farther down, on the richer or damper slopes are the oaks, hickories, and other deciduous species, with shortleaf and loblolly pines.

The natural course of evolution of the longleaf pine forest and its method of reproduction are briefly sketched. The species is intolerant of shade and requires direct overhead light, since the dense terminal clusters of leaves shade the buds from side light.

The chief danger to which the southern forests are subject, is doubtless fire, hence this is treated at considerable length. The fires in longleaf pine forests are exclusively surface fires, which not only destroy the young seedlings in the grass, but injure the butts of the older trees, causing often considerable damage. The frequency of fires, set either accidentally or purposely for burning over grass lands, makes imperative the employment of rangers and the construction of fire lanes about commercial forests. As a rule, seedlings of one or two years' growth are destroyed by surface fires, but older plants usually escape total destruction by virtue of their thick bark and the dense head of long needles that not only protect the terminal bud but form a miniature fire screen by hanging down about the short stem to the ground. Frequent fires will, however, kill even these older seedlings, to say nothing of their destructive action on the humus.

The future silvicultural treatment of these forests is considered in Chapter 8. The forest must be perpetuated as well as exploited. Cutting to a diameter limit of 16 inches has been recommended. In some cases, a method of clear cutting with reserve trees left for seeding the cut over area will probably be found good. The aim of future management will also be partly to bring these forests into a more uniform condition instead of their present great irregularity.

Although more extended tables as to rates of growth and volumes might have been added, this little book will no doubt serve its purpose in helping the lumberman and the general reader to a better understanding of the proper study and treatment of our southern pine forests. The volume is handsomely printed and fully illustrated.

G. M. ALLEN.

Purple-producing Bacteria.[1] — The Purpurbacteria make an interesting group with certain characteristics differing from the majority of these plants. Many bacteria, in fact most of them, grow best in the absence of light, but the group of the Purpurbacteria grow best or as well in its presence. Most pigment-producing bacteria show color production best or only in the free access of oxygen — the group under consideration have the opposite characteristic that they produce their color best or only in the absence or in a diminished supply of oxygen. The color of most bacteria is outside of the cell, but with this group it is in the bacterial cell for the most part.

The author has brought together the known facts in regard to this group, has added some new methods of cultivation, and has contributed descriptions of a number of new varieties isolated by himself. He has furthermore studied more fully the action of light and other conditions on their growth and pigment-producing powers, so that the physiological characteristics of the group are clearly presented in detail. The plates include two of photomicrographs of some of the new varieties described in the text, a presentation of the appearance of bacteriopurpurin crystals from one of them, the color scheme of bacteriochlorin and bacteriopurpurin — the first in alcohol and the second in bisulphuret of carbon — and a number of absorption spectra of the pigments from different members of the group. The book is an interesting and important contribution to the study of the subject.

H. C. Ernst.

GEOLOGY

Rate of Recession of Niagara Falls. — Bulletin 306 of the United States Geological Survey, which has recently been issued,[2] is of much interest to the layman as well as to the student of geology. G. K. Gilbert traces the early development of the ideas that the falls are

[1] Die Purpurbakterien nach neuen untersuchungen. Eine mikrobiologische studie von Prof. Dr. Hans Molisch: Direktor des pflanzenphysiologischen institutes der K. K. Deutschen Universität in Prag. Mit 4 tafeln. Jena, Verlag von Gustav Fischer. 1907. pp. vii, 95, Octavo.

[2] Gilbert, W. K. and Hall, W. C. Rate of Recession of Niagara Falls (by G. K. Gilbert) accompanied by a report on the survey of the crest (by W. Carvel Hall). *Bull. U. S. Geol. Sur.* No. 306, 1907. pp. 1–31, 11 plates, 8 figures.

receding upstream, that the gorge below the falls is the result of this recession, and that it would be possible, by sufficiently accurate observations, to determine the rate of recession. He then discusses the data upon which computations of the rate of recession must be based, consisting of surveys of the crest-line of the falls made in 1842, 1875, 1886, 1890, and in 1905; and camera-lucida sketches made in 1827. After considering the relative accuracy of the different surveys and sketches, and platting the results together, the author concludes that a gradual recession of the Horseshoe Falls is demonstrated, while a much slower rate of recession is indicated for the American Falls. These changes are strikingly represented by contrasted photographs and sketches made from the same view-point, but many years apart.

Concerning quantitative results of the study, the author points out that the available data may be treated in a variety of ways, and made to yield widely divergent results. The lack of harmony is due in part to inaccuracies in the surveys, some of which are unavoidable; and in part to the fact that the rate at which the limestone crest breaks away is necessarily irregular. Too much confidence should not, therefore, be placed in exact mathematical expressions of the rate of recession. In general, however, the evidence proves a recession of about 5 feet a year with a possible error of not more than 1 foot, for the Horseshoe Falls, in the sixty-three years from 1842 to 1905; and a recession of less than 3 inches a year for the American Falls, in the seventy-eight years from 1827 to 1905.

The time consumed in the total recession of the falls from their former position near Lewiston is not considered in this report, except that the author briefly notes some of the many variable factors which must be taken into account in estimating such time. A short report by W. Carvel Hall on the latest survey of the crest line of the falls is appended to the paper.

A sprinkling of "reformed" (one is tempted to say "deformed") spelling throughout the paper occasionally distracts the reader's attention from the matter itself to the manner in which it is presented.

D. W. JOHNSON.

PUBLICATIONS RECEIVED

From June 1 to July 1, regular exchanges not included
The year of publication, when not otherwise noted, is 1907

CRESSON, A. *Les Bases de la Philosophie Naturaliste.* Paris, Félix Alcan, 1907. 178 pp. 2 fr. 50.— HOLDER, C. F. *Half Hours with Mammals.* New York, American Book Company, 1907. 12mo, 253 pp., illus. 60 cents.— KORSCHELT, E. *Regeneration und Transplantation.* Jena, Gustav Fischer, 1907. 286 pp., 144 figs. 7 Mk.— MOLISCH, H. *Die Purpurbakterien.* Jena, Gustav Fischer, 1907. 95 pp., 4 pls. 5 Mk.— VERWORN, M. *Erforschung des Lebens*, 1907. Naturwiss. Wochenschrift, vol. 22, no. 18; printed separately by Gustav Fischer, Jena, 1907. 45 pp. 1 Mk. 80 Pf.

ARNOLD, R. New and characteristic species of fossil mollusks from the oil-bearing Tertiary formations of southern California. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 525–546, pls. 38–51.— BARTSCH, P. A new parasitic mollusk of the genus Eulima. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 555–556, pl. 53.— CLARK, A. H. A new species of crinoid (Ptilocrinus pinnatus) from the Pacific coast with a note on Bathycrinus. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 551–554.— CLARK, A. H. Eighteen new species and one new genus of birds from eastern Asia and the Aleutian Islands. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 467–475.— CLARK, A. H. On a collection of crinoids of the genus Eudiocrinus from Japan, with description of a new species. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 569–574.— CLARK, A. H. Two new crinoids from the North Pacific Ocean. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 507–512.— DYAR, H. G. Descriptions of new species of moths of the family Cochlidiidae. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 565–567.— HAHN, W. L. Notes on mammals of the Kankakee Valley. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 455–464.— JORDAN, D. S. and HERRE, A. C. A review of the lizard-fishes or Synodontidæ of the waters of Japan. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 513–524.— JORDAN, D. S. and STARKS, E. C. List of fishes recorded from Okinawa or the Riu Kiu Islands of Japan. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 491–504.— JUDAY, C. A study of Twin Lakes, Colorado, with especial consideration of the food of the trouts. *Bull. U. S. Bur. Fisheries*, vol. 26, pp. 147–178, pl. 3.— LAMBE, L. M. Notes on the fossil corals collected by Mr. A. P. Low in 1904. *Geol. Sur. of Canada*, 9 pp.— LAMBE, L. M. Note on the occurrence of a supernumerary tooth in a dog. *Ottawa Nat.*, vol. 21, pp. 25–26, 1 fig.— LAMBE, L. M. On a tooth of Ovibos, from Pleistocene gravels near Midway, B. C. *Ottawa Nat.*, vol. 21, pp. 15–18, pl. 1.— LEWTON-BRAIN, L. A lecture on rind disease of the sugar-cane. *Div. Path.* and *Phys., Exp. Sta. Hawaiian Sugar Planters' Assn.*, bull. 7, 38 pp., 16 illus.— MERRILL, G. P. On a peculiar form of metamorphism in siliceous sandstone. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 547–550, pl. 52.— PERKINS, J. The Leguminosæ of Porto Rico. *Cont. U. S. Nat. Herb.*, vol. 10, pt. 4, pp. 133–220.— PERKINS, R. C. L. and KIRKALDY, C. W. Parasites of leaf-hoppers; Leaf-hoppers. *Div. Ent., Exp. Sta. Hawaiian Sugar Planters' Assn.*, bull. 4, 66 pp.— PINCHOT, G. The forest service. *U. S. Dept. Agric., For. Ser.*, cir. 36, 38 pp.— POHL, O.

Basaltische Ergussgesteine vom Tepler Hochland. *Arch. f. naturwiss. Landesdurchforschung v. Böhmen*, 1905, vol. 13, no. 3, 72 pp., 2 pls.— RUTTNER, F. Die Mikroflora der Prager Wasserleitung. *Arch. f. naturwiss. Landesdurchforschung v. Böhmen*, 1906, vol. 13, no. 4, 46 pp., 6 figs.— SMITH, E. H. The blossom end rot of tomatoes. *Mass. Agric. Exp. Sta.*, bull. 3, 19 pp.— STEJNEGER, L. A new Gerrhonotine lizard from Costa Rica. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 505–506. — STEJNEGER, L. A new salamander from Nicaragua, *Proc. U. S. Nat. Mus.*, vol. 32, pp. 465–466. — WARD, H. B. Iconographia parasitorum hominis. *Stud. Zool. Lab., Univ. of Neb.*, no. 70, 20 pls. — WELLER, S. Descriptions of new species of Ordovician fossils from China. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 557–563.— WILDER, B. G. What Agassiz did for Cornell University. *Cornell Era*, vol. 39. — WILLISTON, S. W. The skull of Brachauchenius, with observations on the relationships of the Plesiosaurs. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 447–489, pls. 34–37. — WOHNIG, K. Trachytische und Andesitische Ergussgesteine vom Tepler Hochland. *Arch. f. naturwiss. Landesdurchforschung v. Böhmen*, 1904, vol. 13, no. 1. 24 pp., 1 pl.— WOODRUFF, F. M. The birds of the Chicago area. *Chic. Acad. of Sci., Nat. Hist. Sur.*, bull. 6, 221 pp., 11 pls.

BOLETIM MENSAL DO OBSERVATORIO DO RIO DE JANEIRO, Jan., Feb., Mar., 1906.— FORTY-NINTH ANNUAL REPORT OF THE HORTICULTURAL SOCIETY OF MISSOURI.— NINETEENTH ANNUAL REPORT OF THE RHODE ISLAND EXPERIMENT STATION.— NINTH ANNUAL ANNOUNCEMENT OF THE UNIVERSITY OF MONTANA BIOLOGICAL STATION.— RECORDS OF THE CANTERBURY MUSEUM, vol. 1, no. 1. — TIJDSCHRIFT DER NEDERLANDSCHE DIERKUNDIGE VEREENIGING, 2nd series, vol. 10, no. 3.— WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, bull. 15.

(No. 487 was issued July 17, 1907).

To Zoologists and Museums

W. F. H. ROSENBERG

IMPORTER OF EXOTIC ZOOLOGICAL SPECIMENS

57 HAVERSTOCK HILL, LONDON, N. W., ENGLAND

Holds the largest stock in the world of specimens in all branches of Zoology.

Just published, my new Price List of **Bird-skins,** containing over 4,300 species from all parts of the world.

Also Price Lists Nos. 3, **Mammal skins, skeletons,** and spirit specimens, (over 300 species), and 5, Reptiles, Batrachians, and Fishes (over 300 species),

Any of the above lists sent post free on application.

ARE YOU INTERESTED IN PHOTOGRAPHS OF BIRD-LIFE?

Then you should send One Dollar for a year's subscription to

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

Edited by J. GRINNELL.

"The photographic illustrations alone are worth the price of subscription."
—*The Critic.*

Contributors in the past have included—
Robert Ridgway, Dr. A. K. Fisher, Vernon Bailey, Maj. Mearns, Florence Merriam Bailey, Joseph Grinnell, W. K. Fisher, Louis A. Fuertes, E. W. Nelson, F. S. Daggett, Joseph Mailliard, and other well known ornithologists.

SUBSCRIPTION, $1.00. SAMPLE COPY, 20 CENTS.

H. T. CLIFTON, BUS. MGR., P. O. BOX 404, PASADENA, CALIF.

School Science and Mathematics

A MONTHLY JOURNAL FOR SCIENCE AND MATHEMATICS TEACHERS

It is the only magazine of its kind published in the English language. It gives new ideas and methods of scientific and mathematical instructions—and acts as a clearing house for all that is advanced and good in scientific and mathematics instruction. It is the official organ of many science and mathematics teachers' associations.

EIGHT DEPARTMENTS—Botany, Chemistry, Earth Science, Mathematics, Metrology, Problems, Physics and Zoology.

"Almost a necessiry." Bruce Fink, Professor of Botany, Iowa College.
"The practical hints are valuable to teachers." H. C. Cooper, Ass't Professor of Chemistry, Syracuse University.
"I value the magazine highly. It is most excellently conducted." John S. Collins, Ass't Supt. of Schools, St. Louis, Mo.
"The Problem Department is very interesting and adds greatly to the value of the magazine." H. E. Cobb, Professor of Mathematics, Lewis Institute, Chicago.
"I do not intend to dispense with the magazine as long as it continues as helpful as it has proven to be in the past." Etta M. Bardwell, Biology Department, High School, Ottumwa, Ia.
"I feel that 'School Science' should be in every high school. I shall be glad to further the interests of the journal whenever it is possible." W. M. Cobleigh, Department of Physics, Montana State college of Agriculture.
"I wish to express my appreciation of your magazine. It is a most helpful and inspiring pastime to read the sensible, to-the-point articles it contains." W. T. Heilman, Instructor in Mathematics, Central High School, Columbus, O.
"Your paper is not in the usual class of school papers. I wish to help along the kind of work you are doing." Geo. P. Bristol, Director Summer Session, Cornell University.

$2.00 PER YEAR. 25 CENTS PER COPY.

SCHOOL SCIENCE AND MATHEMATICS

440 KENWOOD TERRACE, CHICAGO, ILL.

SCHOOL SCIENCE AND MATHEMATICS will be sent for THREE MONTHS for 50 cents to a new subscriber mentioning The American Naturalist.

Leading Scientific Text-Books

Millikan and Gale — First Course in Physics

A SIMPLE objective presentation of the subject as opposed to a formal and mathematical one, intended for third-year high-school pupils.

Since its publication in May, 1906, it has been adopted in some of the best schools in the country.

A LIST OF LABORATORY EXPERIMENTS IN PHYSICS has been issued to accompany this book.

Linville and Kelly — Text-Book of General Zoölogy

AN exposition of the science of zoölogy, presented without the interpolation of a laboratory guide.

A large portion of the book is devoted to the insects and vertebrates, because young students are more familiar with these groups, and so take greater interest in them.

Norton — Elements of Geology

THE essentials of the science of geology are treated with fullness and ample illustration in this text-book for beginners.

The presentation is exceptionally simple and the inductive method is emphasized throughout.

Bergen's Botanies

BERGEN'S botanies were the first to combine a standard text, a practical laboratory course, and a key for systematic work. The combination of these three things brought them at once into a leading position among botany texts, — a position they have since maintained.

Principles of Botany (just published). (Bergen and Davis)

Elements of Botany (Revised Edition)

Foundations of Botany

NOTEBOOK TO ACCOMPANY BERGEN'S TEXT-BOOKS OF BOTANY
or for general use in botanical laboratories.

McPherson and Henderson — Elementary Study of Chemistry

IN thorough harmony with the most recent developments in chemistry, both in respect to theory and discovery. Especial attention has been given to the practical applications of chemistry, and to the description of the manufacturing processes in use at the present time.

Hough and Sedgwick — The Human Mechanism

Blaisdell — Physiologies

Young — Astronomies

Williams — Chemistries

Wentworth and Hill — Physics

Davis — Physical Geography

Higgins — Lessons in Physics

Davis — Elementary Physical Geography

GINN & COMPANY Publishers

BOSTON :: NEW YORK :: CHICAGO :: LONDON

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS
WILLIAM E. CASTLE
EDWIN G. CONKLIN
CHARLES B. DAVENPORT
HERBERT S. JENNINGS
FRANK R. LILLIE
JACQUES LOEB
THOMAS H. MORGAN
GEORGE H. PARKER
CHARLES O. WHITMAN
EDMUND B. WILSON

ROSS G. HARRISON, Managing Editor

CONTENTS OF VOLUME IV

NO. 1, FEBRUARY, 1907

Abnormal Development of Toad Ova Fertilized by Spermatozoa Exposed to the Roentgen Rays . . . . . Charles R. Bardeen
An Ecological and Experimental Study of Sarcophagdae with Relation to Lake Debris . . . . . William B. Herms
Rejuvenescence as the Result of Conjugation . . . . . Sara White Cull
Artificial Parthenogenesis in Thalmessema Mellita . . . . George Lefevre
Concerning the Theory of Tropisms . . . . . Jacques Loeb
The Mechanism of the Galvanotropic Orientation in Volvox Frank W. Bancroft

NO. 2, MAY, 1907

The Influence of External Factors, Chemical and Physical, on the Development of Fundulus Heteroclitus . . . . Charles R. Stockard
The Energy of Segmentation . . . . . Edward G. Spaulding
Movement and Problem Solving in Ophuria Brevispina . . . Otto C. Glaser
The Occurrence of a Sport in Lina Lappomica and its Behavior in Heredity . . . . . Isabel McCracken
Experiments in Transplanting Limbs and Their Bearing upon the Problems of the Development of Nerves . . . . . Ross G. Harrison
Factors in the Regeneration of a Compound Hydroid, Eudendrium ramosum . . . . . A. J. Goldfarb

PRICE OF SUBSCRIPTION PER VOLUME

(PAYABLE IN ADVANCE)

To subscribers in the United States, Canada and Mexico	$5.00
To subscribers in other countries	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to the Journal of Experimental Zoology

ADDRESS ALL COMMUNICATIONS TO

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

N. E. Cor. Wolfe and Monument Streets

BALTIMORE, MD., U. S. A.

The first of a series of Colored Plates of the

THRUSHES

OF

NORTH AMERICA

By FUERTES & HORSFALL,

was published in BIRD-LORE for February.

The series will be concluded this year

20 CENTS A COPY. $1.00 A YEAR

THE MACMILLAN CO.

NEW YORK CITY

THE AMERICAN JOURNAL OF SCIENCE

Established by BENJAMIN SILLIMAN in 1818

The Leading Scientific Journal in the United States

Devoted to the Physical and Natural Sciences, with special reference to Physics and Chemistry on the one hand, and to Geology and Mineralogy on the other.

Editor: EDWARD S. DANA

Associate Editors: PROFESSOR GEORGE L. GOODALE, JOHN TROWBRIDGE, W. G. FARLOW, and WM. M. DAVIS, of Cambridge; PROFESSORS A. E. VERRILL, HENRY S. WILLIAMS, and L. V. PIRSSON, of New Haven; PROFESSOR G. F. BARKER, of Philadelphia; PROFESSOR JOSEPH S. AMES, of Baltimore; MR. J. S. DILLER, of Washington.

Two volumes annually, in **monthly numbers** of about 80 pages.

This Journal ended its *first* series of 50 volumes as a quarterly in 1845; its *second* series of 50 volumes as a two-monthly in 1870; its *third* series as a monthly ended December, 1895. A FOURTH SERIES commenced in January, 1896.

Subscription price $6.00 per year or 50 cents a number, postage prepaid in the United States; $6.40 to foreign subscribers of countries in the Postal Union. A few sets on sale of the *first*, *second*, and *third* series at reduced prices. *Ten-volume index numbers* on hand for the second and third series.

THE AMERICAN JOURNAL OF SCIENCE

NEW HAVEN, CONN.

FOR BIRD STUDENTS AND BIRD LOVERS EVERYWHERE.

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

EDITED BY J. GRINNELL.

OFFERS IN VOLUME 9

In MAKE-UP, the highest grade in paper, typography and illustration and every detail that counts.

In ILLUSTRATION, the best work of Messrs. Finley and Bohlman, work that is unsurpassed in any field.

In SUBJECT MATTER, the results of recent studies by active workers in the western field; interest and scientific value, the standard.

SUBSCRIPTION, $1.50 PER YEAR. SAMPLE COPY, 30 CENTS

H. T. CLIFTON, BUSINESS MANAGER, P. O. BOX 404, PASADENA, CAL.

For Summer Reading

What could be better than a Three-Months' Trial Subscription to

The Living Age?

One dollar will bring you this Magazine every week for three months

Containing

THE BEST FICTION
THE BEST ESSAYS
THE BEST LITERARY CRITICISM
THE BEST TRAVEL ARTICLES
THE ABLEST DISCUSSIONS OF PUBLIC AFFAIRS

With the whole range of contemporary English periodicals from the Quarterlies to Punch, to select from, THE LIVING AGE is able to give its readers every week a larger variety of material written by the most brilliant writers than any other single magazine.

THE LIVING AGE has been published every Saturday without missing an issue for more than 63 years and was never more indispensable than now to intelligent readers.

TERMS: SIX DOLLARS A YEAR

Three-Months' Trial Subscription one dollar

The Living Age Company

6 BEACON STREET, BOSTON

VOL. XLI, NO. 489 SEPTEMBER, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	The Structure of Cilia, especially in Gastropods	LEONARD W. WILLIAMS	545
II.	The Poison Glands of Noturus and Schilbeodes	HUGH DANIEL REED	553
III.	The Structure of the Silk Glands of *Apanteles glomeratus* L.	ROBERT MATHESON and A. G. RUGGLES	567
IV.	The Nest of the Kelp Fish	CHARLES F. HOLDER	587
V.	Notes and Literature: *General Biology;* Specific characters in early embryos. — *Zoology;* New text books of zoology. — Books of nature study. — Birds of Labrador and of the Chicago area. — The excess of male births. — Recent publications concerning the structure of insects. — Stridulation rhythm of crickets. — Notes. *Botany;* Plant geography. — Lock on Progress in the study of variation, heredity, and evolution. — Notes.		589
VI.	Publications Received		606

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALES HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley.*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology, Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *September, 1907* No. 489

THE STRUCTURE OF CILIA, ESPECIALLY IN GASTROPODS

LEONARD W. WILLIAMS

WE venture to present the following incomplete observations in the hope that they may contribute to the solution of the difficult problem of the structure of cilia.

While looking over fresh marine plankton from Narragansett Bay, we came upon an unidentified but common larva of a protobranch mollusk whose velar cilia were so large that they were exceptionally favorable for study. With a cover glass upon the larva, we were able to watch with increasing ease the successive ciliary waves which gradually became less frequent and rapid as the animal died; and consequently we were able to study the individual cilia in detail. A groove with overhanging edges follows the rim of the velum, and the large preoral cilia are arranged in a row along the posterior edge of this groove. Each cilium is large and somewhat curved, being concave on the side toward which the effective stroke is directed. It tapers evenly from its basal body to its apex. The protoplasm at the base of the cilium was seen to contract alternately on the opposite sides of the basal body and, correspondingly, to move the base of the cilium back and forth. In contracting, the protoplasm draws the cuticula downward.

As already stated, the cilia are arranged in a row along the edge of a groove. The contraction of the protoplasm upon the lower side of the cilium draws its base into the groove while the lower portion of the cilium is bent so as to fit into the groove and the upper portion is carried backward a few degrees (Fig. 1, *a* and *b*). The convex side of the cilium is thus drawn into the groove. The

contraction of the protoplasm above the cilium carries its base upward, and cramps the cilium against the overhanging edge of the groove until the lower portion of the cilium is bent into an S-shaped curve (Fig. 1, *c* and *d*). The contraction continuing, the cilium is forced past the edge of the groove and flies out and back with a very rapid stroke — the effective stroke of the cilium (Fig. 1, *e*). It is carried by the force of its stroke far beyond its position of rest to which its elasticity brings it back in position for another stroke. There seems no doubt that these cilia are elastic rods (Fig. 2, *g*) which are moved by the contraction of the protoplasm at their bases. The cuticula around the base of the cilium rises and falls with the movement of the cilium as though it formed a plate into which the cilium is set. Consequently it appears that the contractile fibrillae of the protoplasm are inserted in the cuticula and not directly in the base of the cilium. We do not know what part the basal body plays in this movement but we believe that it forms a pivot upon which the cilium turns somewhat as an echinoderm spine turns upon its base.

The cramping and subsequent escape of the cilium account for the rapidity and force of the effective stroke and also explain the well known fact that the cilia of rotifers and veligers always seem to move only in the opposite direction to that which is necessary, since the effective stroke is too rapid to be visible. We do not believe that the groove is a common ciliary structure,— on the contrary it is probably present only in cilia like those mentioned, whose effective stroke is invisible. However, we should call attention to the pits, collars, and ridges at the bases of the flagella and cilia of Protozoa, Porifera, and spermatozoa to which as yet no function has been ascribed.

Almost every cilium whose structure has been made out consists of an axial rod or canal filled with cell sap or protoplasm, and a sheath consisting of cuticle or protoplasm. In the velar cilium described above, we have no doubt that the elastic rod is surrounded by a protoplasmic or cuticular sheath.

The large swimming plates of ctenophores, which are formed by the fusion of a number of cilia, have been carefully studied by Verworn.[1] In the position of rest, the plate is parallel to the sur-

[1] Verworn, M. Studien zur Physiologie der Flimmerbewegung. *Arch. f. d. g. Physiol.*, 1891, 48, p. 149–180.

face of the body and points toward the aboral pole of the animal. Its base is sharply bent toward the aboral pole and its distal portion is concave outward. The contraction of the oral side of the base of the plate first straightens out the basal curve and then bends the base of the cilium over toward the mouth. While the contraction of the base is taking place the distal portion of the plate is first flattened by the resistance of the water and then is bent into a curve of shorter radius by the contraction of its oral side. At the end of the stroke, the cilium is again parallel to the surface

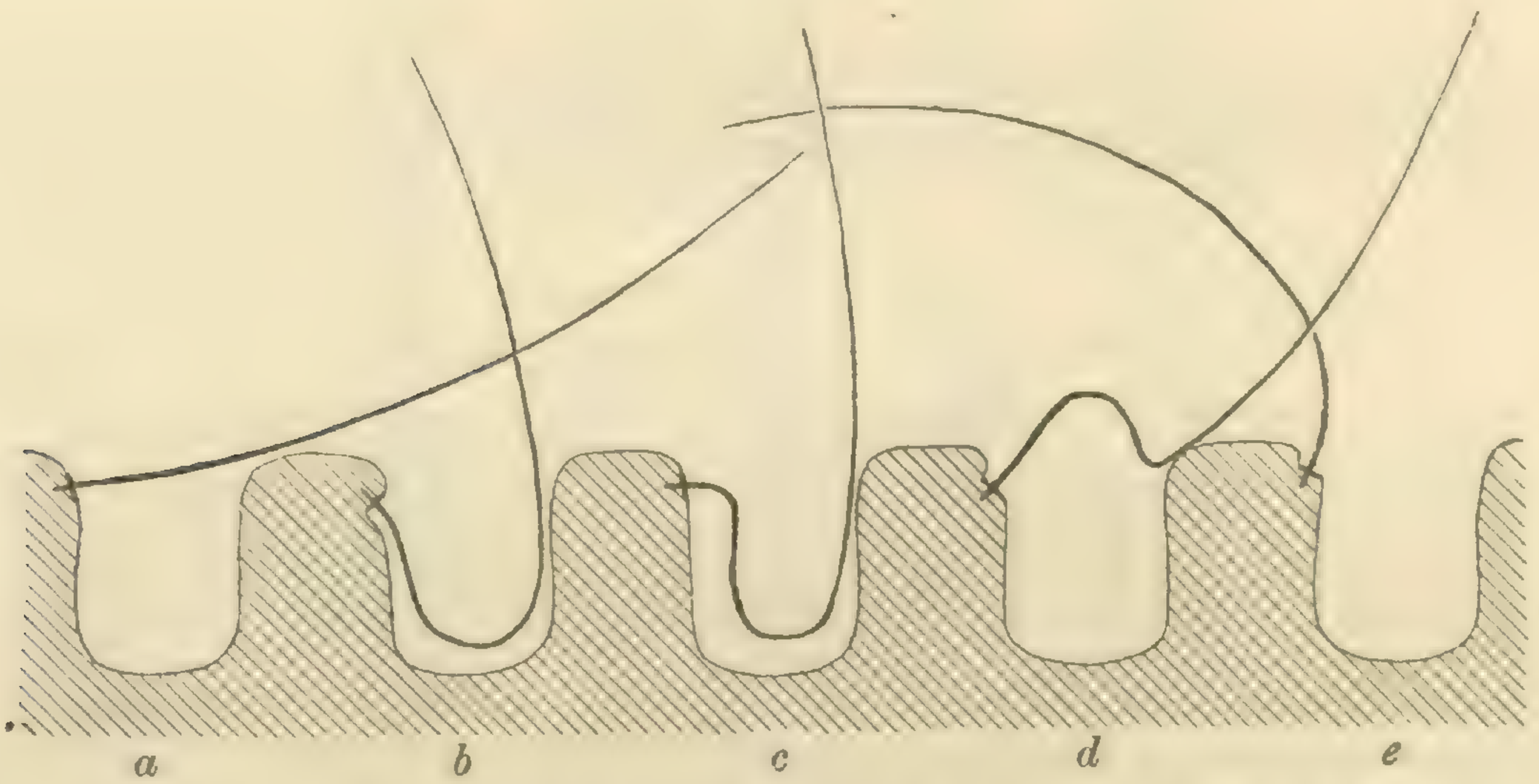


FIG. 1.— Diagram showing successive stages in the stroke of a cilium in the velum of a gastropod larva.

of the animal but it points toward the mouth and its single concavity is directed inward. Smooth muscle fibers pass from the gastric canal, which underlies each row of cilia, to the rib which carries the swimming plates; by their contraction they draw the rib into the gelatinous tissue of the body. Verworn believes that the sole function of these muscle cells is to draw the plates from the surface for the protection of the plates, and also that the movement of the cilium is caused chiefly by the contraction of its base. He does not suggest the existence of an axial supporting rod. It is possible, however, that the muscles underlying the plates may assist in the movements of the cilium and that it is really quite similar functionally to the velar cilia.

The tails or flagella of spermatozoa undoubtedly consist of an

axial rod with a protoplasmic sheath which often bears undulatory membranes. The tails of the vast majority of spermatozoa seem to lack the power of movement when separated from the basal body and cell protoplasm, and we believe that this indicates a dependence of the cilium upon a muscle-like structure around the basal body. In Salamandra, as reported by Meves,[1] and in many protozoa a

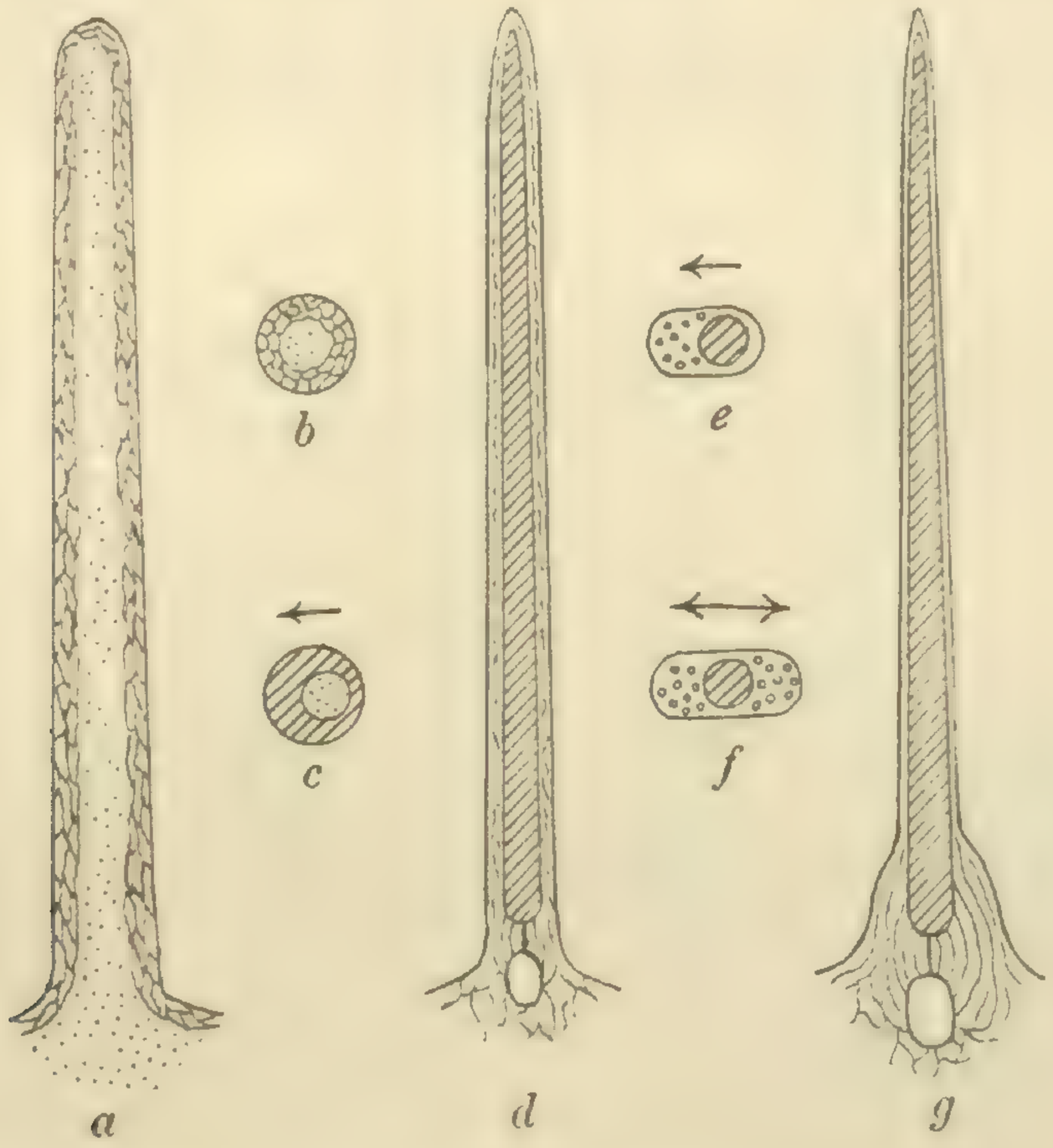


FIG. 2.— Diagram showing the hypothetical structure cilia.
a, primitive cilium with fluid core and contractile sheath.
b, cross section of *a*.
c cross section of a cilium according to Schäfer's theory of ciliary structure.
d, more highly developed cilium with basal body and elastic axial rod.
e, cross section of an irreversible cilium.
f, cross section of a reversible cilium.
g, cilium in which the contractile portion is confined to its base.

flagellum or cilium separated from the basal body and the cell protoplasm is capable of motion. In these cases doubtless the contractile substance is not confined to the base of the flagellum but extends into, perhaps throughout, the sheath (Fig. 2, *d*). The vast majority of cilia and flagella, however, can move only while in connection with protoplasm and the basal body. A different interpretation has been given to these facts by Pütter[2] and

[1] Meves, F. Über Structur und Histogenese der Samenfäden des Meerschweinchen. *Arch. f. mikr. Anat.*, 1899, 54, p. 329–402, vide p. 382.

[2] Pütter, A. Die Flimmerbewegung. *Erg. Physiol.*, 1902, 2, Abth. 2, p. 1–102.

others who consider that the isolated cilium is capable of motion but lacks only the necessary stimulus.

That the core or axis of the cilium is always solid is rendered improbable by the fact that many pseudopodia and the tentacles of the Suctoria, which are admittedly homologous with cilia, clearly have a central canal or a fluid core (Fig. 2, *a*). Moreover the experiments of Zacharias [1] who caused the spermatozoa of Polyphemus to produce slender cilia-like pseudopodia by immersing them in a 5 per cent. solution of sodium phosphate, and of Prowazek [2] who saw the retracting protoplasm of an injured cell thread of *Siphonaea bryopsis* produce in five minutes cilia which beat at the rate of 40 strokes a minute, and who [3] also found in Chilomonas cilia appearing as small processes which in 8 minutes attained half their normal size and beat 19 times in 20 seconds, show that certain cilia must consist of but slightly modified protoplasm. These experiments also indicate that a solid or a permanent core is not always formed, for in the first two cases the cilia were quickly destroyed. It is clear that a tube containing a fluid which cannot escape either because of the cell turgor or because enclosed in the tube, will act precisely as an elastic solid. In this connection Gurwitsch's [4] discovery that a marked increase in cell turgor accompanies the formation of cilia, and the cases of contraction of the cell or movements of the nucleus indicating such contraction, synchronously with the stroke of the cilia of the cell, all suggest that the turgor holds in, or the contraction of the cell forces into, the cilium the fluid which forms its support. This consideration in turn suggests a function for the ciliary roots which may increase the turgor of the cell by drawing its walls together.

These various considerations have been utilized in the current theories of ciliary action and structure, especially in the most generally accepted theory which is supported with various modi-

[1] Zacharias, O. Über die Amöboiden Bewegungen der Spermatozoen von Polyphemus pediculus. *Zeit. f. wiss. Zool.*, 1885, 41, p. 252–258.

[2] Prowazek. Protozoenstudien II. *Arb. a. d. Zool. Inst. Univ. Wien*, 1900, 12, p. 243–300.

[3] Prowazek. Protistenstudien III. *Arb. a. d. Zool. Inst. Univ. Wien.* 1902, 14, p. 81–88.

[4] Gurwitsch, A. Studien uber Flimmerzellen. I. Histogenese der Flimmerzeller. *Arch. f. mikr. Anat.*, 1901, 57, p. 184–229.

fications by Engelmann,[1] Pütter, Parker[2] and Gurwitsch.[3] According to this theory, the cilium consists of an axial support and a contractile protoplasmic sheath. The nature of the axis has been less the subject of discussion than that of the sheath which Engelmann regards as fibrillar, Pütter as protoplasm with temporary fibrillar arrangements, and Gurwitsch as protoplasm of changing surface tension. As stated above, Verworn thinks that the cilium of ctenophores is formed of two columns of contractile protoplasm whose differential contraction moves the cilium, and Engelmann seems to lean toward this view.

Less generally accepted theories are those of Benda and Schäfer. Benda[4] believes that the cilium is passive and is operated by a mechanism at its base, but the cases cited above of the movement of cilia entirely separated from the basal body and the cytoplasm, and the failure with few exceptions to find such a mechanism, make this view unacceptable. The velar cilia above described, the existence in some cells of the hypobasal layer which seems to consist of contractile protoplasm, and the partial agreement of Verworn's observations upon ctenophore cilia suggest, however, that although this theory will not apply to all cilia, it is the only theory which explains the action and structure of certain cilia.

Schäfer[5] regards the cilium as an elastic tube (Fig. 2, *c*), one side of which is less elastic than the rest, into which fluid flows or is forced causing the cilium to bend over toward its less elastic side.

This theory is plausible and the structure is mechanically possible but it fails to explain some points, as, for example, the reversal of ciliary action and the presence of axial rods in spermatozoan flagella. It seems, however, that the action of the suctorian tentacles which are evaginated and invaginated like the finger of a glove can only be explained by this theory.

[1] Engelmann, T. W. Cils Vibratils, in Richet's *Dictionaire de Physiologie*, Tome 3, 1898, p. 785–799. See also older works by the same author.

[2] Parker, G. H. The Reversal of Ciliary Movement in Metazoans. *Am. Journ. Physiol.*, 1905, 13, p. 1–16.

[3] Gurwitsch, A. Morphologie und Biologie der Zelle. Jena, 1904, vide p. 76 ff.

[4] Benda, C. Über neuer Darstellungsmethoden der Centralkörperchen. 1901. *Arch. f. Anat. und Physiol., Physiol. abth.*, 1901, p. 147–157.

[5] Schäfer, E. A. Theories of ciliary movement. *Anat. Anz.*, 1904, 24, p. 497–511. See also *Anat. Anz.*, 1905, 26, 517–521, and *Proc. Royal Soc. London*, 1891, 41, 193–198.

The generally accepted theory is undoubtedly correct but it can now be stated more fully than heretofore and can be, in a measure, harmonized with the less acceptable theories. All protoplasmic processes, cilia, flagella, pseudopodia, and suctorian tentacles, are of essentially the same structure and consist of a contractile protoplasmic sheath which encloses a solid or fluid supporting core. Primitively the sheath (Fig. 2, *a*) is contractile throughout and is not marked off structurally or functionally from the remainder of the ectoplasm. Secondarily the sheath becomes differentiated into contractile and noncontractile portions, the relations of which are shown in the following examples. The contractile protoplasm (Fig. 2, *g*) of velar cilia and ctenophore plates is practically confined to the base of the cilium. Parker has shown that in reversible cilia (Fig. 2, *f*) the contractile substance must occur in two opposite bands which in Metridium are on the oral and aboral sides of the supporting axis. Ordinarily the aboral band contracts more strongly than the other and drives water away from the mouth but certain organic and inorganic substances cause the oral band to contract more strongly and so to reverse the direction of the effective stroke and of the currents caused by it. Parker shows also that irreversible cilia (Fig. 2, *e*) probably have but one band of contractile material. Ballowitz[1] has shown that spermatozoan flagella have a fibrillar axial structure surrounded by a sheath of uneven thickness and Pütter with others have shown that the axial rod supports the irregular contractile protoplasmic sheath.

The core of the pseudopodium, which is to be regarded as the simplest cilium, is fluid. In higher stages of ciliary development a solid, which is elastic in cilia and flagella and inelastic in pendulous pseudopodia, replaces the fluid core.

HARVARD MEDICAL SCHOOL
Boston, Mass.

[1] Ballowitz, B. Untersuchungen über die Structur der Spermatozoen, zugleich ein Beitrag zur Lehre vom feineren Bau der kontractilen Elemente. *Arch. f. mikr. Anat.*, 1888, 32, p. 401–473.

THE POISON GLANDS OF NOTURUS AND SCHILBEODES

HUGH DANIEL REED

The eleven species of Noturus and Schilbeodes are popularly known as "stone cats" and "mad toms." They are small catfishes found in the lesser streams from New York and New Jersey west to Wyoming and Montana, and south to Georgia, Alabama and Texas, being most abundant in the Great Lake, Ohio and Upper Mississippi regions. They may be distinguished from other catfishes by the presence of a *keel-like* adipose fin joined to the back and more or less continuous with the caudal fin. The two genera, which appear very much alike, may be distinguished from each other by means of the pad of villiform teeth on the upper jaw. In Noturus this pad of teeth, at each outer caudal angle, possesses a backward extension which is absent in Schilbeodes.

It has long been known that the mad toms can inflict a painful wound with their pectoral spines. The sensations produced by the wounds, and the presence of a pore in the axilla, have led to much speculation respecting the presence of a poison-secreting gland which anoints the spine. Some take it for granted that such an organ exists, others are doubtful, and recently the presence of poison glands in these fishes has been denied altogether.

Günther ('80 b) recognized the existence of a sac in the axilla of certain catfishes and says,— "It does not seem improbable that it contains a fluid which may be introduced into a wound by means of the pectoral spine.... However, whether this secretion is equally poisonous in all the species provided with that axillary sac, or whether it has poisonous qualities at all, is a question which can be decided by experiments only made with the living fishes."

Jordan and Gilbert ('82) under the description of the genus Noturus[1] say,— "In or above the axil of the pectoral fins is an orifice, which is the opening of the duct of a poison gland." To

[1] What now constitute the genera Noturus and Schilbeodes were then included under the generic term Noturus.

this is added a quotation from Cope,—"From it [the pore] may frequently be drawn a solid gelatinous style ending in a tripod, each limb of which is dichotomously divided into short branches of regular length." Jordan and Evermann ('96) make a similar statement and add,—"The sting from the pectoral spine is very painful, resembling the sting of a bee, but worse." Again, Jordan ('04) writes the following footnote,—"The wounds produced by the sting of their sharp pectoral spines are excessively painful. In the axil is usually a pore, probably the opening of a duct from a poison gland. This matter deserves investigation." Finally ('05) he writes,—"In two genera, Noturus and Schilbeodes, a poison gland exists at the base of the pectoral spine, and the wound gives a sharp pain like the sting of a hornet and almost exactly like the sting of a scorpion-fish."

Boulenger ('04) does not consider this axillary sac a poison gland. In this connection he says,—"I think this condition of things has nothing to do with a poison organ, and is merely a repetition of what is observed in loaches and in the characinid Xenocharax, where I have found a gelatinous substance filling the short duct by which the membrane of the air bladder is placed in communication with the skin and the sensory organ of the lateral line."

Poison organs in connection with various spines have been found in several different groups of fishes. Günther ('69) has described a poison apparatus in *Thalassophryne reticulata* which inflicts a wound followed by poisonous symptoms. At the base of the dorsal and opercular spines in this species he found a sac connected with a canal passing through the whole length of the spine and opening through a slit at its distal extremity. Thus the spine resembles the fang of a poisonous snake. Günther concluded by saying, "Nobody will suppose that a complicated apparatus like the one described can be intended for conveying an innocuous substance and therefore I have not hesitated to designate it as poisonous; and Capt. Dow informs me in a letter lately received, that 'the natives of Panama seemed quite familiar with the existence of the spines and of the emission from them of a poison which, when introduced into a wound, caused fever, an effect somewhat similar to that produced by the sting of a scorpion;

but in no case was a wound caused by one of them known to result seriously. The slightest pressure of the finger at the base of the spine caused the poison to jet a foot or more from the opening of the spine'."

The weever fishes (Trachinus) found along the coast of Europe inflict very severe wounds with their dorsal and opercular spines. This was so well known that in some towns, at one time, there were regulations providing for the removal of the spines before the fishes were displayed in the markets. Schmidt ('75) and Parker ('88) independently found well developed glands about the dorsal and opercular spines. There are numerous references to the poisonous nature of the weever fishes, but the two authors mentioned are the only ones, so far as I know, who have described the structure of the glands.

Wallace ('93) in the toadfish, *Opsanus* (*Batrachus*) *tau*, discovered glands in connection with pores in the axilla, on the dorsal portion of the operculum and on the surface of the pectoral fin. This author does not consider them as poison glands although the spines of this species give a "slightly painful sting" and the glands apparently are of the same type as those of the weever fishes described by Schmidt and Parker, and those of the mad toms to be described presently.

With the above facts and views in mind and a desire to know more of the action and structure of the supposed poison glands, all the known species[1] of Noturus and Schilbeodes, except *S. funebris*, have been examined. The sting will be described first, and then the structure of the glands.

The Sting.— The sting of the mad toms has been described as like that of a bee. In *Schilbeodes gyrinus* the sensations produced do not differ materially from those of a bee but as a rule the pain is not so intense and is usually confined to the wounded region. Frequently a very severe sting upon the end of the finger caused pain throughout the hand and wrist. In several cases after receiving deep punctures on the end of the finger, sharp pains which continued for several hours, were experienced to the elbow. Dr.

[1] The author wishes to acknowledge his indebtedness to Dr. C. H. Eigenmann, Dr. B. W. Evermann and the authorities of the National Museum for the generous loan of specimens for study.

Evermann (MS.) describes the pain as, "A very stinging sensation, more like that which would result from a severe nettle sting.' This describes precisely the majority of stings, for in handling live specimens ordinarily only the tip of the spine enters the flesh. The mechanical injury is so slight that it frequently is impossible to locate the wound except for the stinging sensation. From an ordinary sting, such as is received in handling the live fishes, the pain continues from one to several hours, depending probably upon the amount of poison entering the wound. Both in sensation and duration these wounds differ from those made by the prick or puncture of a sharply pointed instrument. The swelling is hardly perceptible,[1] except in cases of very severe punctures, in which event the flesh about the wound becomes distinctly swollen

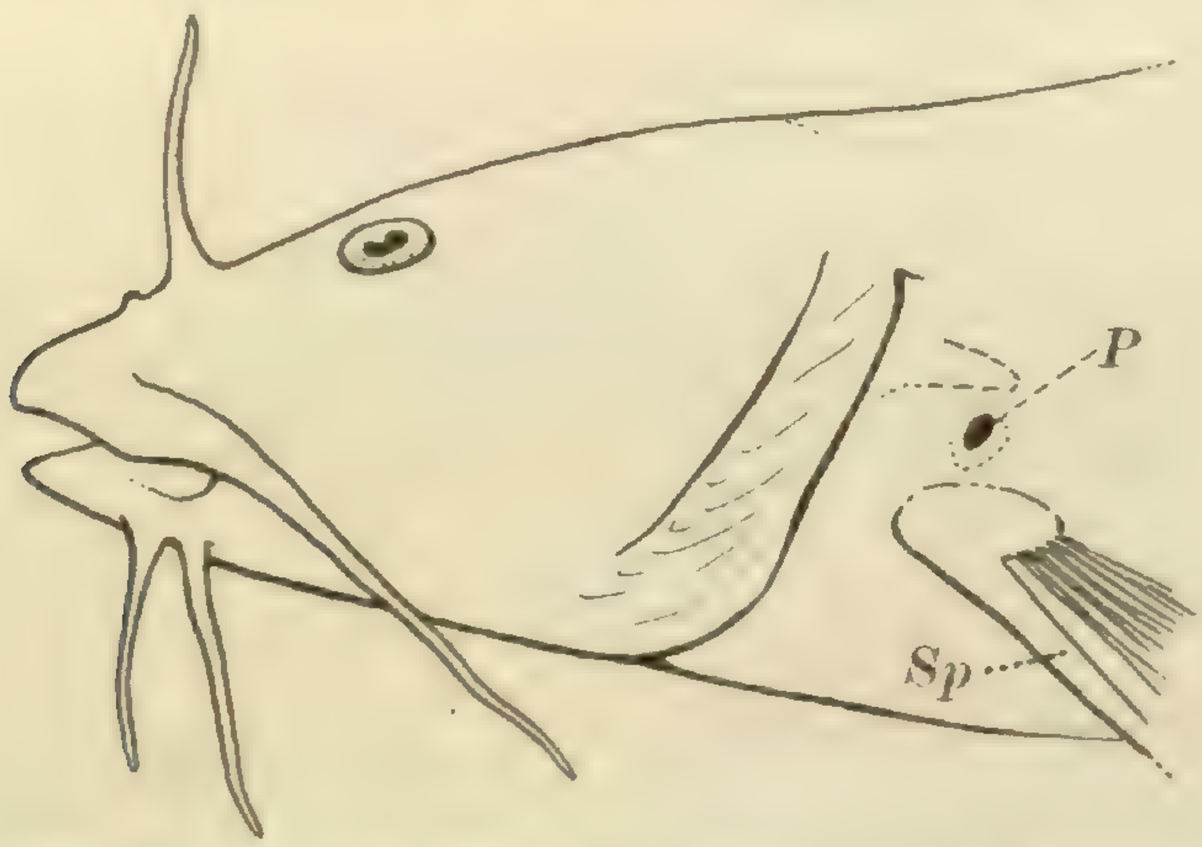


FIG. 1.— The head of *Noturus flavus*. *P*, axillary pore or opening of axillary gland. Sp, pectoral spine.

and slightly discolored. Similar results, but more marked, are produced by introducing a portion of a fresh gland underneath the skin.

The Poison Glands.— All the species of Noturus and Schilbeodes possess axillary glands which open through a pore situated in the axilla just below the post humeral process (Fig. 1, *P*). The position of the pore with reference to the base of the fin and the humeral process varies somewhat in different species. In all, the pore is more or less slit-like and is situated so that when the fin is adducted the spine lies either directly across or parallel with it. Thus the transfer of secretions to the spine may be accom-

[1] *Schilbeodes gyrinus* was the only species available for experimentation. Some other species of the genus are said to be more virulent.

plished during adduction but it is doubtful if this is the usual method of anointing the spines. In most of the species the pore is opened widely when the fin is abducted. In *Schilbeodes insignis* the lips of the pore, if anything, are drawn closer together by the abduction of the fin. In approaching each other, however, the lips of the pore are continued to the base of the spine as two slight folds with a groove between them. Thus the secretions would find a safe conduit from the pore to the spine.

The glands are pear-shaped, with the apex toward the axillary pore (Fig. 2, p. g. and p. o.). In most species examined, the gland is inclined backwards and lies just beneath the skin and entad of the posthumeral process (Fig. 2, h). It is surrounded by loose connective and adipose tissue. In *S. gyrinus* the gland extends farther towards the head than in some other species. In all species the gland, though small, is macroscopic. In a specimen of *Noturus flavus* 17 cm. long the greatest diameter of the gland was 5 mm.

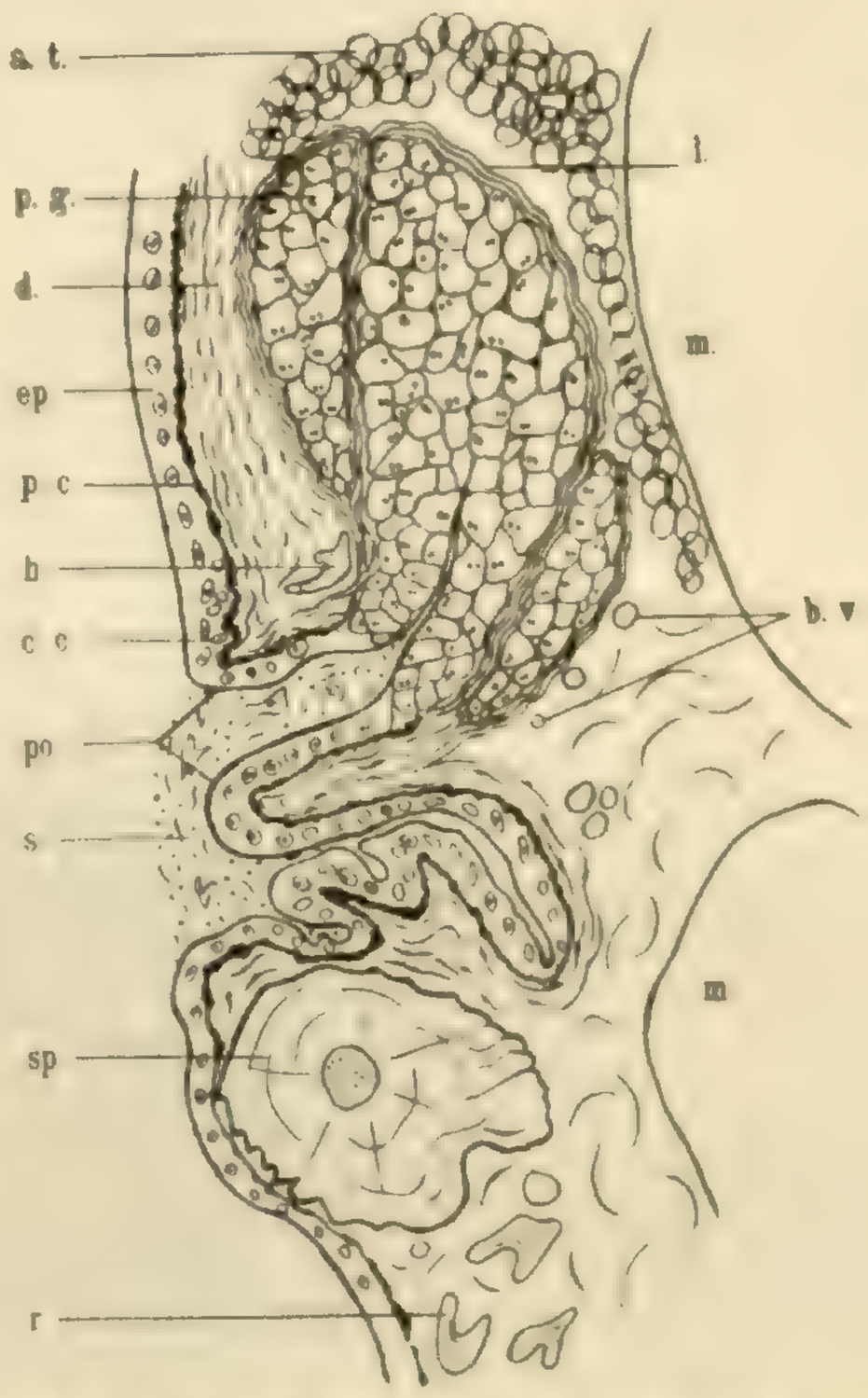


FIG. 2.— Section through the axillary gland and pectoral spine of *Schilbeodes mirurus*. *a. t.*, adipose tissue. *p. g.*, axillary poison gland. *d.*, corium. *ep.*, epidermis. *p. c.*, layer of pigment cells. *h.*, post-humeral process. *c. c.*, clavate cells of the epidermis. *po.*, axillary pore. *s.*, secretion. *sp.*, pectoral spine. *r.*, fin-ray. *l.*, sheath of the gland. *m.*, muscle. *b. v.*, blood vessels.

The glands are divided into three main lobes, each of which is subdivided into lobules. The lumen of the gland is extremely narrow except near the pore where it is comparatively wide. It can be traced in sections however, through the main lobes and for a short distance into the subdivisions. The tripod style which Cope withdrew from the pore was probably the hardened secretion of the gland, each of the three legs of the style corresponding to the lumen of the three main divisions of the duct and the dichotomous branches repre-

senting the lumens of further subdivisions. I have frequently found globular masses of the secretion filling and depending from the pore (Fig. 2, s) but have been unable to withdraw one with the branches intact. The secreting cells are granular and very large. They range between 80 and 200 microns in their greatest diameter, and vary in shape due to compression with neighboring cells. Most of the cells contain two large nuclei. As a rule the two nuclei are separated by a short space, but frequently they are found very close together or apparently joined. This may indicate recent division as Parker has suggested in con-

FIG. 3.— Transection of the dorsal spine of *Schilbeodes gyrinus*. *pg*, poison gland. *ep*, epidermis. *sp*, dorsal spine. *r*, fin-ray.

nection with similar phenomena in the poison glands of the weever fishes. Further evidence of division has not been apparent.

The entire gland is surrounded by a sheath which reaches the bottom of the fissures between the primary and secondary lobes. (Fig. 2, l). Every secreting cell is lodged in a loose network of elongated spindle-shaped cells which Schmidt has named supporting cells. Each has a nucleus in its central part. The gland is richly supplied with blood vessels which are lodged in its sheath and between its lobes.

Besides the axillary glands, two species, *Schilbeodes gyrinus* and *S. nocturnus*, each possess glands beneath the skin which covers the dorsal and pectoral spines. Both spines are situated in front of and are shorter than the first soft rays of their respective fins. Both are grooved, as shown in the transection Fig. 3, sp. Near the base of the spines the grooves are more complex. If an uninjured specimen be examined, at the middle of the extent of these spines there will be noticed a swelling which tapers towards either end. The gland (Fig. 4, pg) is coextensive with this swelling and occupies nearly all of the space between the skin and the spine which it surrounds (Fig. 3, pg). At the end of the spine there is a slit in the epidermis through which the spine projects slightly. In preserved specimens it is not unusual to find a globular mass or a long filament of the hardened secretion attached to the end of these spines. The sting of the dorsal spine in *Schilbeodes gyrinus* is precisely like that of the pectoral. The

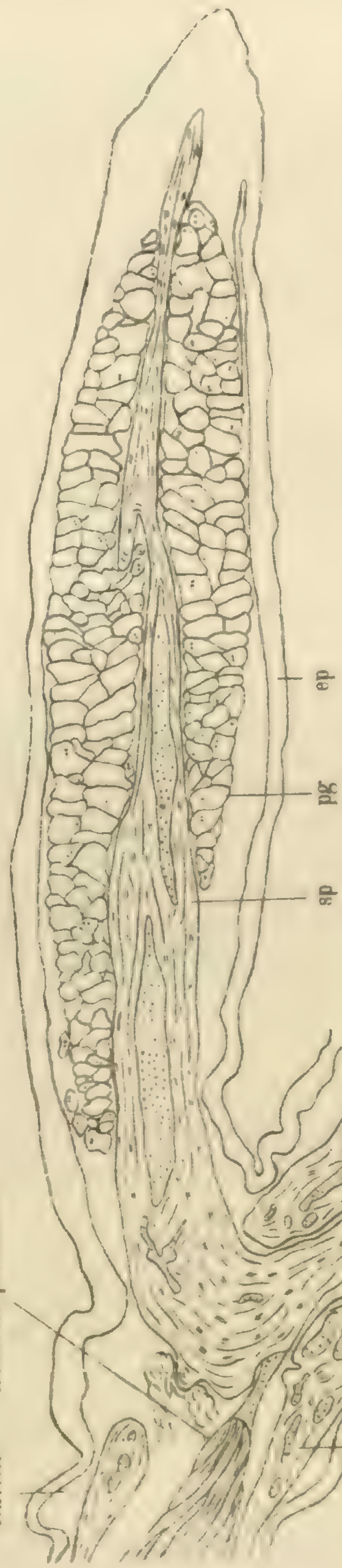


FIG. 4.— Longitudinal section of the pectoral spine of *Schilbeodes gyrinus*. *sp*, pectoral spine. *pg*, poison gland. *ep*, epidermis.

same will probably be found true of *S. nocturnus* for the dorsal spine gland is here as well developed as the pectoral. The presence of spine glands may be determined by carefully slitting the overlying skin and scraping the spine with a needle. If the gland is present, the scrapings when stained and mounted show the typical gland structure almost as clearly as sections. Sometimes the structure can be made out with a dissecting lens without either staining or scraping the tissue from the spine. In the fresh condition the glands are of a translucent jelly-like consistency and appearance. There is no difference in structure between the axillary and spine glands.

It appears from the figures and descriptions of Schmidt and Parker that the poison organs of the mad toms and the weever fishes are identical in structure. In the latter group the glands are found only in connection with the opercular and dorsal spines which they surround in precisely the same manner as do the pectoral and dorsal glands of *Schilbeodes gyrinus* and *S. nocturnus*.

Differential stains fail to reveal the presence of any muscular fibers which might by their contraction exert pressure upon the cells and force their secretions to the exterior. The same is true according to Schmidt and Parker of the weever fishes. The latter ('88) writes,— "No special muscles are present in connection with the glands. . . . I am inclined to think that in the discharge of their secretions the cells simply burst." Schmidt ('75) observes that "Along the ventral side of the upper gland are found a few bundles of the extensor muscle of the gill cover but they could hardly produce any pressure on the gland, and moreover, no organ, adapted for active ejection of the secretion, is found." It appears that the cells are destroyed when the secretions are released, for in no case has a natural opening been found in the cells, and the secretions when stained are found to contain ruptured and ragged cells in many of which the nucleus can still be made out. Frequently uninjured cells are found floating in the secretions along with the ruptured ones. Usually these are small cells, probably immature ones, which have been torn away with the others.

The relation of the fin and body muscles to the gland is such that no amount of contraction can produce any pressure upon it.

It is improbable that the glands depend upon the application of external pressure, such as would result if the fish were seized in the axillary region by another animal. It is doubtful whether, in those species which possess spine glands, the spines are ever inserted far enough into the flesh of the victim to produce pressure as a result of the slipping of the skin away from the tip and towards the base of the spine. Such was Byerley's ('49) explanation of the ejection of the poison from the glands of the weever fishes but it was not accepted later by Schmidt and Parker. Judging from the size of the wound inflicted by these forms which possess spine glands, the exposed portion of the spine is probably as much as is usually inserted into the flesh. It seems probable that the cells of both axillary and spine glands are ruptured from the outward pressure exerted by their own contents. The ruptured cells are not found in one place but are scattered through the gland, and the secretion may be seen streaming through the lumen and pore, out along the folds of skin on the dorsal surface of the spine toward its tip. In specimens which have been carefully handled a globule will be found depending from the axillary pore or a stream of the secretion extending from it to the pectoral spine. The end of the pectoral and dorsal spines in *Schilbeodes gyrinus* is usually found with a globule or wavy filament of the poison. Thus always supplied with poison at its very tip it can be readily understood how the slightest prick produces results.

It is worthy of note that spine glands are found only in those species where serrae upon the spines are absent or very few and weak. A serrate dorsal spine without a gland apparently cannot inflict a stinging wound, but the non-glandular serrate pectoral spines are supplied with poison from the axillary glands. Although no difference in the relative size or specialization of the axillary glands in the two groups has been noted, the species with serrae are considered more poisonous than those without. The presence of serrae makes possible the infliction of a large number of wounds and consequently the introduction of a large amount of poison at one and the same time. This would render such species more formidable although the poison is secreted in smaller quantities and is no more virulent. Certainly spines without serrae can inflict wounds from the tip end only and being some distance from

the axillary pore would most likely be poorly provided with poison except for the presence of a gland opening at the very end. It seems plausible, therefore, that the absence of serrae is correlated with the presence of glands developed about the spines, as in *Schilbeodes gyrinus* and *S. nocturnus* and as probably will be found in *S. leptacanthus* [1] when an uninjured individual is examined.

The Origin of the Gland Cells.— Cutaneous glands are generally to be regarded as invaginations or proliferations of the epidermis, certain cells of which become transformed into the secreting cells. Wallace ('93) has shown that in the axillary glands of the toadfish the clavate cells of the epidermis become the secreting cells, whereas

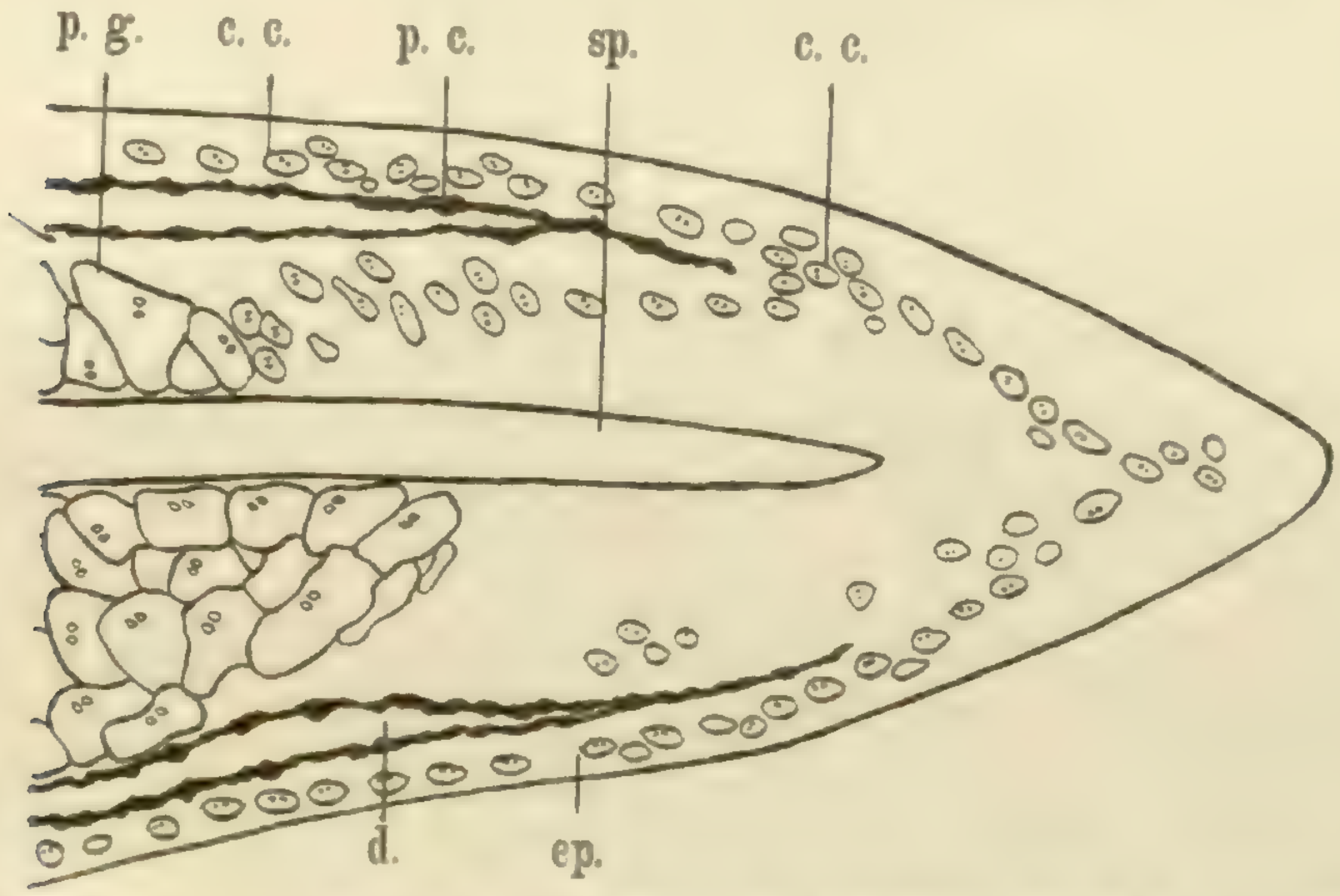


FIG. 5.— Longitudinal section of the end of the pectoral spine of *Schilbeodes gyrinus*. *p. g.*, poison gland. *c. c.*, clavate cells. *p. c.*, layer of pigment cells. *sp.*, pectoral spine. *d.*, corium. *ep.*, epidermis.

the smaller cells become the supporting elements. Similarly, in writing of the weever fishes, Schmidt says,— "After a comparison of the contents of the gland sac and the adjacent epidermis it seems clear that in the gland tissue the secreting cells replace the clavate cells and that the ordinary epidermal cells are gradually transformed into the supporting plexus." Parker calls attention to the lack of well defined ducts in the glands of the weever fish. He says,— "There can be little doubt that the gland is developed as an epidermic involution the whole of which gives rise to secre-

[1] The only specimen available was a very small one, the spines of which had been denuded of all tissue whatsoever.

tory cells, so that there is no marked differentiation into gland and duct."

The glands in Noturus and Schilbeodes are likewise invaginations of the epidermis. They are surrounded by a sheath of corium pushed inward by the developing gland. As shown in Fig. 2, *d* and *l*, the sheath is thinner and denser than the rest of the corium, with which it is continuous around the neck of the gland. Between the corium and epidermis in most regions of the body there is a layer of pigment cells (Fig. 2, p. c.) which is frequently found to extend about the gland between the sheath and the gland tissue, thus occupying the same relative position as in the skin. The arrangement of the pigment layer in relation to the spine glands shows that they are invaginated from near the tip of the spine. Near the tip, the pigment layer (Fig. 5, p. c.) turns upon itself and passes over the gland to its base, toward the root of the spine. Thus the gland is invested by two layers of pigment cells with corium between them (Fig. 5, d). The clavate cells of the skin and the secreting cells of the gland form an uninterrupted series (Fig. 5, c. c. and p. g.), the former gradually increasing in size so that in sections it is sometimes impossible to draw the line between the two. The other cells of the epidermis as the gland is approached, gradually assume an irregular shape, then becoming more elongated they are finally transformed into the extremely slender cells which constitute the supporting tissue.

The invagination is much more extensive and the specialization of elements proceeds much further in the mad toms than in the toadfish. In the glands of the latter the epidermal character of the cells is barely lost. Thus the slime cells, which in the mad toms are apparent only in the skin, according to Wallace's figures are perfectly distinct in the glands of the toadfish, and project into the gland cavity.

Summary

1. All of the species of Noturus and Schilbeodes, except *S. funebris*, have been examined; they are found to possess an axillary pore which is the opening of a gland.

2. Experiments with *Schilbeodes gyrinus* indicate that the secretions of the glands are poisonous.

3. In addition to the axillary glands *Schilbeodes gyrinus* and *S. nocturnus* possess glands developed about the pectoral and dorsal spines. These are of the same type and structure as the axillary glands. The end of such a gland-bearing spine projects slightly through a slit in the epidermis.

4. Spine glands are not found in those species which possess well developed serrae upon the spines.

5. *Schilbeodes leptacanthus*, because of its close relation to *S. gyrinus*, would be expected to possess spine glands in addition to the axillary glands.

6. A study of the mature glands tends to justify the following conclusions:

a. The glands are of epidermal origin; those in the axilla invaginate from the pore, and those in the spines from the slits near the tips of the spines.
b. The gland sheath is modified corium.
c. The clavate cells of the skin become the secreting cells of the gland.
d. The ordinary epidermal cells become elongated, forming the supporting network of the secreting cells.
e. The glands of the mad toms are essentially like those of the weever fishes.
f. The glands of the toadfish, although of the same type, are intermediate in structure between the glands of the mad toms and unmodified epidermis.
g. There are no muscles for rupturing the cells and forcing out the secretion. The cell walls are evidently ruptured by the pressure of their contents. In this way the spines are constantly anointed with the poisonous secretion as may be seen by examining uninjured specimens.

CORNELL UNIVERSITY
ITHACA, N. Y.

LITERATURE.

ALLMAN, G. J.

'41. On the Stinging Property of the Lesser Weever. (Trachinus). *Ann. Nat. Hist.* 1841, vol. 6, p. 161.

BOULENGER, G. A.

'04. The Cambridge Natural History, *Fishes, Ascidians, etc.*, 1904, vol. 7, p. 590. Macmillan Co., N. Y.

BRIDGE, T. W.

'04. The Cambridge Natural History, *Fishes, Ascidians, etc.*, 1904, vol. 7, p. 177. Macmillan Co., N. Y.

BYERLEY.

'49. Poison of Weever Fishes. *Proc. Literary and Philosophical Soc.*, Liverpool, 1849, p. 156.

CHIEVITZ, J. H.

'88. Notice on Professor W. Newton Parker's Communication, "On the Poison Organs of Trachinus." *Anat. Anz.*, 1888, p. 787.

CUVIER. [Remarks upon the poison of the weever fishes]. *Hist. Nat. des Poissons.* T. 3, p. 184.

DAY. [Remarks upon the poison of the weever fishes].

'80–'84. *The Fishes of Great Britain and Ireland*, vol. 1, pp 78–82. London.

GESSIN, LEON.

'84. Contributions à l'étude de l'appareil a venin chez les poissons du genre "vive" (Trachinus). *Thèse de Paris.* 1884.

GÜNTHER, A.

'64 On a Poison Organ in a genus of Batrachoid Fishes. *Proc. Zool. Soc. Lon.*, 1864, p. 157.

'69. An account of the Fishes of the States of Central America Based on Collections made by Capt. J. M. Dowe, F. Godman Esq., and O. Salvin Esq., *Trans. Zool. Soc. Lon.*, 1869, vol. 6, p. 439.

'80 a. Article on "Ichthyology" in *Ency. Brit.*, 1880, vol. 12, p. 190.

'80 b. An Introduction to the Study of Fishes. Edin., 1880. p. 192.

JARDIN, SIR WM.

'43. British Fishes, pt. 1. *Naturalists Library*, 1843, vol. 4 (Ichthyology), pp. 135–137.

JORDAN, D. S.

'04. Manual of Vertebrates. 1904, p. 41, McClurg & Co., Chicago.

'05. A Guide to the Study of Fishes. 1905, vol. 2, p. 177. Henry Holt & Co., N. Y.

JORDAN, D. S. AND GILBERT, C. H.

'82. Synopsis of the Fishes of North America. *U. S. Nat. Mus.*, 1882, bull. 16, p. 98.

JORDAN, D. S. AND EVERMANN, B. W.
'96. The Fishes of North and Middle America. *U. S. Nat. Mus.*, 1896, bull. 47, p. 145.
KENT, W. SAVILLE.
'83. British Marine & Fresh Water Fishes. *Fisheries Exhibition Handbook*, 1883, p. 29. London.
PARKER, W. N.
'88. On the Poison Organs of Trachinus, *Proc. Zool. Soc. London*, 1888, p. 359.
SACCHI, MARIE.
'95. *Atti. Soc. Ligust.*, 1895, vol. 6, p. 89.
SCHMIDT, F. T.
'75. Om Fjarsingens Stik og Giftredskaber. *Nord. Med. Arkiv.*, 1875, vol. 6, nv. 2.
TYBRING, OSCAR.
'86. Poisonous Fishes. (Translated from the Danish by Hermann Jacobson). *Bull. U. S. F. C.*, 1886, vol. 6, p. 148.
WALLACE, LOUISE B.
'93. The Structure and Development of the Axillary Glands of Batrachus. *Journ. Morph.*, 1893, vol. 8, p. 563, pl. 27.
WIEDERSHEIM, R.
'06. Vergleichende Anatomie der Wirbelthiere. 1906, Jena.
WRIGHT, R. R.
'84. *Proc. Can. Inst.*, 1884, vol. 2, p. 252.

THE STRUCTURE OF THE SILK GLANDS OF *APANTELES GLOMERATUS* L.[1]

ROBERT MATHESON AND A. G. RUGGLES.

Apanteles glomeratus is a hymenopterous social parasite of the larvae of *Pieris rapae*, the common cabbage worm. The adult females deposit at each oviposition from fifteen to thirty-five eggs in the young larvae of Pieris. The parasites on hatching, feed upon the lymph and fatty tissue of their host and grow very rapidly, becoming full grown at about the end of the larval life of the caterpillar. They then penetrate through the skin of their host and, while emerging, spin their characteristic sulphur-yellow cocoons. The silk glands, as seen in sections of the mature larvae, are enormously developed. Although the silk glands of lepidopterous and trichopterous larvae have been the objects of detailed study by Helm, Gilson, and others, very little is known concerning these glands in the Hymenoptera. As regards histological structure the only works of importance are those of Cholodkovsky, his student Pikel, and Bordas; and, excepting the latter who gives a brief discussion of these glands in the aculeate Hymenoptera, these writers have confined themselves to the study of the larvae of various Tenthredinidae. Therefore at the suggestion of Professor Riley we were led to investigate more fully the silk glands of Apanteles.

The work was carried on in the Entomological Laboratory of Cornell University. We wish to extend our thanks to Professors Comstock, Riley and MacGillivray, for their constant aid and advice.

Anatomical Disposition of the Silk Glands.— The silk glands of *Apanteles glomeratus* arise near the base of the labium and extend through the body cavity to the antepenultimate segment of the abdomen. In the abdominal region of mature larvae they consist of two pairs of thin-walled, much convoluted, cylindrical tubes (Pl. 1, fig. 3) which completely surround the alimentary

[1] Contributions from the Entomological Laboratory of Cornell University.

canal. Each pair of tubes unites in the first abdominal segment to form a common thoracic division. These common tubes, extending forwards with many convolutions in the thorax, turn ventrad just behind the developing head and passing on each side of the sub-oesophageal ganglion, end in short ducts. These ducts unite in the labial region to form the press which occupies more than half of the common duct.

In young larvae just hatched, and for several days later, the glands show no convolutions whatever. They lie as straight tubes, two on each side of the alimentary canal and extend caudad to the antepenultimate segment (Pl. 1, fig. 1). Moreover the structure is the same throughout their entire length, no regional differences occurring. Their walls are thick and their lumina very small. Later they become much convoluted, and their lumina are greatly distended, till in the mature larvae at time of emergence from the host, the abdominal division has practically ceased to secrete, becoming simply a reservoir for the already accumulated product.

The silk glands may be divided into two general divisions; 1. Secretory. 2. Conducting.

The Secretory Division.— The secreting division may be conveniently divided into two portions, abdominal and thoracic.

The abdominal portion comprises that part of the gland extending caudad from the point of juncture of the glandular tubes in the first abdominal segment.

In the freshly hatched and young larvae this portion consists of two pairs of straight glandular tubes, one pair situated on each side of the alimentary canal (Pl. 1, fig. 1). On each side the tubes lie directly one above the other. No difference in structure between the dorsal and ventral tubes could be detected. In cross section the gland is seen to be composed of two large cells surrounding a very small lumen (Pl. 1, fig. 9). Each cell is almost completely filled by a large unbranched nucleus. Externally lies the basement membrane (*b. m.*), a delicate structureless sheath surrounding the gland. On the inner surface lies a delicate, thin membrane, the structure of which we were unable to make out under the highest powers of the microscope. It appears as a thin, resistent, structureless membrane. Gilson, '90, has worked out in detail its struc-

ture in the larvae of *Bombyx mori*. He concludes his study by stating that the producing portion is clothed by an extremely fine resistent cuticula, in which are found spiral filaments of various thicknesses, united to one another by delicate transverse or oblique trabeculae. He does not consider that these meshes are closed by a structureless lamella but refrains from a positive statement.

As the larvae feed and grow, this portion, during the third and fourth days, commences to become convoluted; the nuclei are larger and somewhat branched; the lumen slightly increases in size. Gradually, as the cells begin to secrete actively, the glandular tubes become more and more convoluted until, at the time of emergence of the parasite from the host, they almost completely fill and greatly distend the perivisceral cavity. These changes are brought out in the longitudinal sections of young and mature larvae respectively, Pl. 1, figs. 2 and 4, and in corresponding cross sections, Pl. 2, figs. 7 and 8.

Along with the great increase in length of the glandular tubes goes a corresponding increase in size. The cells necessarily become larger, but their radial diameter diminishes. The lumen gradually becomes distended by the accumulated product, till, at the time of the spinning of the cocoon, the walls are reduced to a very thin layer (Pl. 1, fig. 11). The figures 9, 10, and 11 show the enormous increase in the size of the lumen during the very short larval life. So great is this increase that either cross or longitudinal sections of an adult larva present a very striking appearance, practically the whole body cavity being monopolized by the silk gland.

The nuclei in the glands of the young larvae are round or oval in shape and fill the greater part of the cells (Pl. 1, fig. 9). As these cells commence actively secreting the nuclei become more and more branched. The shape of the nuclei at nearly four days is shown in Pl. 3, fig. 31; during the latter part of the larval life they appear as if fragmented (Pl. 3, fig. 34). Gilson records complete fragmentation of the nuclei in certain cells of the larger part of the glandular tubes in Bombyx and Trichoptera. Marshall and Vorhies, '06, could not confirm this in the case of *Platphylax designatus* and they also deny the anastomosing of the branches.

In *Apanteles glomeratus*, owing to the thinness of the glandular walls, it was impossible to secure tangential sections which would give surface views of the nuclei. As the nuclei do not stain deeply at this stage, they are rather difficult to differentiate, although we secured fairly good results by staining with Grenacher's borax carmine, as shown in figure 34.

The cytoplasm is dense, granular, and vacuolated, especially during the latter part of the larval life when the glands are at the height of their activity (Pl. 1, figs. 10 and 12). Through the cytoplasm run trabeculae, extending in many cases from the external border to the inner margin of the cell. These trabeculae appear as fine radiating lines, but later, with the thinning of the glandular walls, they disappear.

Gilson, '90, performed some interesting experiments in order to determine the method of secretion. He ligated the entire living larvae, disposing the ligatures in two pairs, the two threads of each pair being close together. He then divided the larva into three sections by cutting between each pair of ligatures. Treating the cut surfaces with mercuric chloride and collodion he secured living isolated portions of the caterpillar, in each of which the silk glands, especially near the ligatures, continued to secrete. In such isolated portions he found vacuoles present in the cytoplasm and even in the nuclei of the silk glands. These vacuoles he considered as the silk secretion. He did not succeed in establishing whether they lay between the radiating trabeculae or not. In the case of *Apanteles glomeratus* the condition which Gilson sought to obtain by mechanical means is the normal one since none of the secreted product is used till at the time of emergence from the host. Numerous vacuoles are present in the cytoplasm, becoming most abundant during the time of the greatest glandular activity. The contents of these vacuoles remain unstained by any of the coloring agents used, but the secreted product is sometimes stained as is noted later. Whether the presence of these vacuoles in the cells is due to the retention of the secreted product in the lumina of the glands remains an open question.

The thoracic portion of the secretory division of the gland consists of but two secreting tubes, lying one on each side of the alimentary canal (Pl. 1, fig. 1). Each is formed by the union of the

two tubes of the abdominal division in the first abdominal segment and extends cephalad to the short duct which begins just in front of the sub-oesophageal ganglion. The thoracic portion may be divided into three well defined parts,— the 1st, or anterior thoracic; the 2nd, or middle thoracic; and the 3rd, or posterior thoracic divisions.

The 3rd, or posterior thoracic, division during the first half of larval life consists of an almost straight cylindrical tube. Later it becomes much convoluted and its walls become thinner so that in every way it markedly resembles the abdominal portion. The cytoplasm is densely granular, deeply staining, and much vacuolated, especially near the periphery of the cells (Pl. 2, figs. 14 and 16).

The 2nd, or middle thoracic division, is quite short and straight. It extends from the beginning of the second thoracic segment to the first division. The cells of this portion of the gland have a greater radial diameter than in any other part. The layer of "gres" or "gum," so prominent in the 1st division, is very thin and in some places difficult to distinguish. The cells are characterized by a faintly staining, loosely granular cytoplasm, which near the periphery of the cells, is much vacuolated (Pl. 1, figs. 19 and 20).

The 1st, or anterior thoracic division, is also short and straight. It extends from the beginning of the first thoracic segment to the duct. This portion of the gland is characterized by a thick dense layer of "gres" or "gum" adhering closely to the inner surface of the secreting cells (Pl. 1, fig. 23; pl. 3, figs. 24 and 30). The cytoplasm of these cells is dense, granular, and deeply staining, contrasting strongly with that of the middle or 2nd thoracic division as shown in Pl. 3, fig. 24.

The nuclei of these divisions differ mainly in the extent of their branching. In the 1st they are not so markedly branched as in the 2nd, and in the 3rd, or posterior division, they are yet more ramifying. The basement membrane is of the same character as in the abdominal divisions. The internal lining of the lumen is more distinct. It appears as a thin, elastic, structureless, cuticular membrane.

A fact worthy of note is the absence of the glands of Philippi.

There is no indication of a vestige of these glands, such as Gilson found in *Limnophilus rhombicus*, one of the Trichoptera.

The Conducting Division.— The conducting portion of the silk glands is Y-shaped, with a median stem and branches pointing caudad; each branch joins the thoracic portion on its respective side of the body. The press commences at the juncture of the two branches. The entire conducting portion is very short, being wholly confined to the labium. In cross section the branches are seen to be composed of a number of cells surrounding a small lumen (Pl. 3, fig. 25). The nuclei are oval to rounded in shape,— never branched. Posteriorly the cells are columnar and contain elongated nuclei, but anteriorly the cells become flattened (Pl. 3, fig. 30). There is thus formed an enlarged lumen at the anterior end of each branch of the conducting tube. Also by the increased radial diameter of the posterior cells the amount of "gres" or "gum" that can pass forward is regulated (Pl. 3, fig. 30).

The cuticular lining of these branches forms chitinous folds or ridges which are not perfect spirals but appear as incomplete rings. (Pl. 3, figs. 25, 29 and 30, *in*).

The Press.— Although the internal disposition of the silk glands was familar to the earlier anatomists, nothing was known regarding the mechanism by which the silk thread was formed and regulated until the time of Lyonet. He designated the entire labium as the "filiere," because it was the instrument which had been given to the caterpillar for spinning. He was the first to demonstrate the presence of the press with its attached pyramidal muscles, but he did not succeed in working out its structure. He concluded by supposing that this organ acted as a pump to draw up the silk from the glandular tubes and to force it to the exterior.

Dr. Azoux, '49, in his classic model of the silk worm, represents with exactness these pyramidal muscles of the press.

Helm, '76, was the next worker who added anything new regarding this organ. His figures and descriptions of its structure are not at all exact yet he arrives at correct conclusions regarding its function. He considered it to act simply as a press in the formation of the silk thread. It was not till the important works of Gilson and Blanc that the minute structure of this organ in Lepidoptera and Trichoptera was known and its functions clearly defined.

Berlese, '06, denies the presence of a press in the silk glands of the larvae of Hymenoptera, Diptera, and Coleoptera. He figures a sagittal section of the head of the larva of *Xylotoma rosae* but does not represent muscles as present in the region of the conducting tube. On the other hand the presence of a press in hymenopterous larvae has been recorded by Eckstein, '90, in *Lyda pratensis*, and Pikel, '96, in *Lophyrus pini*. Both of these workers figure this organ as present but give no definite details regarding its structure. Pikel states that in structure it is similar to that described by Tichomirow for *Bombyx mori*.

Structure of the Press.— In the case of *Apanteles glomeratus* the press is highly developed. It commences at the union of the two conducting tubes in the region of the labium and occupies more than half of the common duct. Dorsally the press is concave, traversed by a longitudinal furrow into which pass the dorsal pair of muscles as shown in cross and longitudinal sections in Pl. 3, figs. 27, 29 and 30. The ventral surface is convex (Figs. 27 and 30); its cells are somewhat elongated and secrete the thicker chitinous layer of the common duct. The dorsal muscles consist of numerous fibers which are attached directly to the chitin along the longitudinal median furrow as shown in figures 27 and 29. Emerging from this furrow the muscles separate laterally and, passing dorsocaudad, are inserted on the chitinous layer of the floor of the buccal cavity (Fig. 27). The ventral muscles are each composed of several fibers. They are located as shown in cross section in Fig. 27. They are inserted on opposite sides of the press and, passing almost directly ventrad, have their origin on the ventral body wall, being attached directly to the chitin.

The lumen of the press, as seen in cross section (Fig. 27), is horseshoe-like in form. When the muscles are relaxed this lumen is practically closed, thus preventing the further egress of the thread. The lumen is lined with a thick chitinous layer which is more strongly developed on the ventral side. This chitinous layer is directly continuous with that of the ducts. In Fig. 27 the dorsal portion of this layer appears thick, but this is due to the obliquity of the section which was necessary in order to show the muscles in one section.

In very young larvae the press is not yet developed. The dorsal median furrow and the attached muscles cannot be distinguished

and it is not till about three days after hatching that the furrow and attached muscles become clearly differentiated. Being functional for such a short time its complete development does not take place till late in the larval life. It is not till shortly before emerging from its host that the press becomes completely developed as it is not necessary that it should be fitted for spinning during the entire lifetime of the larvae but only for the very short time occupied in the building of its cocoon.

In structure the press differs from that described for Lepidoptera in that the lateral pair of muscles is not present, and from that of the Trichoptera in that each dorsal muscle is single and not divided into two distinct bundles as figured by Gilson.

Functions of the Press.— The functions of the press in the Lepidoptera have been carefully worked out by Gilson and Blanc and there is no doubt that the functions of this structure in the Hymenoptera are similar. These functions may be summed up as follows,—

1. The press modifies and regulates the form and diameter of the two threads.

2. It regulates the layer of "gres" or "gum" which surrounds these threads.

3. By the relaxation of the muscles the chitinous walls, on account of their elasticity, contract and hold the thread immovable as in a vise.

Gilson attributes to the press another function, that of forcing the thread to the exterior when by accident or voluntarily the thread is broken in the spinneret. This is denied by Blanc who holds that the contraction of the muscles of the press, distending its lumen to the fullest extent, together with the pressure upon the contents of the gland due to the elasticity of its walls, and the general muscular contractions of the body, serve to force the thread to the exterior when broken in the spinneret or even in the conducting tube.

In the case of *Apanteles glomeratus* we do not think the press possesses the latter function attributed to it by Gilson, inasmuch as the pressure exerted by the elastic walls of the abdominal portion and the general contractions of the somatic muscles along with that of the muscles of the press, seem to us a more correct explana-

tion of how the thread is first forced to the exterior and also how it is extruded when broken.

It is not necessary for us to describe the mechanism of spinning as that has been fully done by Blanc and Gilson for the Lepidoptera and their descriptions serve equally well for the hymenopterous larvae. The method of spinning the cocoon in *Apanteles glomeratus* has been well described and figured by Reaumur.

The Spinneret.— From the press a short chitinous tube leads to the spinneret (*sp.* Figs. 28, 29 and 30). The lumen of this tube gradually widens as it approaches the exterior (Figs. 29 and 30). The entire length of the common duct is .875 mm., of which the press occupies .4 mm. The spinneret is situated just beneath the buccal cavity and consists of two small chitinous projections directed cephalo-dorsad (Fig. 28, *sp.*).

Functions of the Different Parts of the Silk Gland.—*Abdominal Division.* As previously pointed out the abdominal division of the silk glands consists, in the young larvae, of two pairs of straight cylindrical tubes lying on each side of the alimentary canal. As the larvae grow these parts become active, their lumina become gradually distended with the secreted product till, in the mature forms, the glandular walls are so thin as to warrant the assertion that they have practically ceased to secrete and are merely reservoirs for the accumulated product.

The question as to whether the "gres" or "gum" is secreted by one particular region of the gland and the silk by another is still unsettled. Gilson in 1890 and again in 1894 came to the conclusion that both are secreted throughout the gland; and that the silk, properly speaking, is the result of a selection effected in the layer of secreted product lying next the internal face of the cells. Whether this process of selection is a chemical phenomenon or merely a physical separation, he does not attempt to decide. From a study of several series of sections he concludes that the outer or cortical layer of the secretion is granular in appearance and has special affinity for coloring agents. Neither of these conclusions is absolute since he did not find them to hold true in all cases.

Blanc, '89, p. 24, states that "The silk secreted in the posterior part of the gland is discharged continuously into the reservoir and, on its arrival there, it is surrounded by a new material which is

formed in this region. This substance is the 'gres.'" He considers (pp. 27–28) the "gres" as nothing more than the peripheral layer of silk oxidized in the reservoir, the oxidation being due to the presence of a large number of tracheae in this region.

In the abdominal portion of the silk glands of *Apanteles glomeratus* the secretion appears as a hyaline, faintly staining product. Fixation in Flemming's solution and staining with iron haematoxylin gives it a greenish color, the peripheral portion often being black. In the anterior part of the abdominal portion the peripheral layer is always stained black. Safranin colors the entire secretion salmon color, the peripheral layer always more deeply, especially in the anterior part of the abdominal portion. Mayer's acid haemalum and eosin do not color it at all.

Judging from the staining properties of the secretion the conclusion that there is a differentiation between the peripheral layer and the central column appears justified. Whether this peripheral layer is the "gres" or not is a question which we do not pretend to answer.

Thoracic Division. This portion of the gland remains actively secreting much longer than the abdominal division. The characteristic appearance of an actively secreting portion is shown in Pl. 2, fig. 16. The peripheral area often appears less deeply stained and numerous vacuoles are always present.

The character of the secretion in the posterior thoracic division appears similar to that of the abdominal portion except that the peripheral layer has a greater radial diameter and that vacuoles are generally more numerous. It also takes the same characteristic colorations.

The anterior and middle thoracic portions secrete a somewhat different product. The character of the cells of the middle portion would indicate that such is the case here at least. Fixation in Fleming's solution and staining with iron haematoxylin gives to this division a very characteristic appearance. The cytoplasm is filled with rather large rounded black granules thus easily differentiating this portion from the other two thoracic divisions. The nature and function of these granules we were unable to determine. In similarly treated glands many identical black granules are seen near the internal surface of the cells just within the internal membrane. These granules are present in all parts of the gland except the first thoracic division (Pl. 1, figs. 10 and 12).

The dense secretion covering the inner surface of the 1st thoracic portion indicates that this is its own peculiar product and not that of the following division. This secretion appears closely striate in a radial manner. Acid haemalum and eosin do not color it; iron haematoxylin, safranin, and Grenacher's borax carmine stain it but slightly. The central column of silk, however, is more densely stained with iron haematoxylin and safranin.

As the glands of Philippi are not present it is only speculation to suppose that the secretion of the second thoracic portion may be of a nature similar to that of these glands in the Lepidoptera. The function of the product of the glands of Philippi is not definitely known. Nearly all workers differ in their conclusions in regard to this question. The conclusion of Blanc, '91, and Berlese, '06, based upon the experiments of Robinet, '39, seems the most logical. These authors consider its function that of lubricating the thread which is to pass through the press.

The fact that the thread, in *Apanteles glomeratus*, begins to take on its definite form at the posterior end of the 1st thoracic portion might indicate that the secretion of the 2nd division had a coagulating effect upon the silk and "gres."

Summary

1. The silk glands of *Apanteles glomeratus* differ from those in the Lepidoptera and Trichoptera in that there are four tubes in the abdominal region. Their histological structure is similar to that of Lepidoptera and Trichoptera but differs markedly from that described for the tenthredinid larvae.

2. In immature larvae the epithelial cells of the whole producing region are actively secreting. Numerous vacuoles are present in these secreting cells, especially near the periphery.

3. In glands fixed in Flemming's solution and stained with iron haematoxylin there are present, near the inner margin of the secreting cells, many black rounded granules. These are very abundant in the 2nd thoracic portion and absent in the 1st thoracic portion. Their nature and function we were unable to determine.

4. In mature larvae the abdominal division becomes greatly

distended and nearly fills the entire body cavity. It is probable that this portion now acts merely as a reservoir and that its cells have ceased secreting.

5. The glands of Philippi are absent and it is probable that the second thoracic portion performs the functions of these glands.

6. The press is well developed. It differs from that of the Lepidoptera in that the lateral pair of muscles is absent, and from that of the Trichoptera in that there is a single pair of dorsal muscles rather than two distinct pairs.

7. The product of the gland is a double thread as in the Lepidoptera and Trichoptera.

CORNELL UNIVERSITY
Ithaca, N. Y.

BIBLIOGRAPHY

BERLESE, ANTONIO.

1907. Gli Insetti, loro organizzazione, sviluppo, abitudini e rapporti coll'uomo. 1907, vol. 1, pp. 521–523.

BORDAS, L.

1895. Appareil glandulaire des Hymenopteres. *Ann. Sci. Nat. Zool.*, 1895, vol. 19, pp. 12–20.

CARRIÈRE AND BÜRGER.

1897. Die Entwicklungsgeschichte der Mauerbiene (Chalicodoma muraria Fabr.) im Ei. *Nova Acta Acad. Leop. Car.*, 1897, vol. 69, No. 2, pp. 342–350.

CHOLODKOVSKY, N.

1895. Entomotomische Miscellen, I. Ueber die Spinndrüsen der Tenthredinidenlarven. *Horae Soc. Ent. Ross.*, 1895, vol. 29, pp. 145–149, pl. 2.

1901. Ueber den Spinnapparat der Lyda-Larven. *Allgem. Zeit. f. Ent.*, 1901, vol. 6, pp. 17–19.

ECKSTEIN, K.

1890. Zur Biologie der Gattung Lyda. *Zool. Jahrb.*, 1890, Abth. f. Sys. 5, p. 427, pl. XXXV.

DE GEER, K.

1752–'78. Memoirs pour servir a l'histoire des Insectes. Stockholm.

GILSON, G.

1893. On Cytological Differences in Homologous Organs. *63rd Rept. Brit. Ass. Adv. Sci.*, 1893, pp. 813–816.

HENNEGUY, L. F.
1904. Les Insectes, 1904, p. 466.
KIRBY AND SPENCE.
1828. An Introduction to Entomology. 1828, vol. 3, p. 125.
KOLBE, H. J.
1893. Einführung in die Kentniss der Insekten. 1893, p. 623.
NEWPORT, G.
1852. Anatomy and Development of Certain Chalcididae and Ichneumonidae, compared with their special economy and instincts. *Trans. Linn. Soc. Lond.*, 1852, vol. 22, pp. 61–67.
PIKEL, V.
1896. Zur Frage über die Spinndrüsen der Tenthrediniden-larven. *Horae Soc. Ent. Ross.*, 1896, vol. 30, pp. 122–128, Taf. VIII.
POLETAJEW, N.
1885. Ueber die Spinndrüsen der Blattwespen. *Zool. Anz.*, 1885, pp. 22–23.
RAMDOHR, K. A.
1811. Abhandlung über Verdauungswerkzeuge der Insecten. 1811, pp. 58–65 and p. 143.
SEURAT, L. G.
1899. Étude des Hyménoptères Entomophages. *Ann. Sci. Nat.*, 1899, (8) 10, p. 62.
WESTWOOD, J. O.
1840. Classification of Insects. 1840, vol. 2, p. 78.
PEREZ, C.
1901. Histolyse des tubes de Malpighi et les glandes sérigène chez la Fourmi rousse. *Bull. Soc. Ent. Fr.*, 1901, pp. 307–310.
WHEELER, W. M.
1898. The Embryonic Development of the Wall Bee (Chalicodoma muraria Fab.). *Am. Nat.*, 1898, vol. 32, pp. 794–798. A review of Carrière and Bürger's work.

EXPLANATION OF THE FIGURES.

Fig. 1, pl. 1.— Optical section of a young larva shortly after hatching, showing the arrangement of the silk glands. (*s. g.*). ×

Fig. 2, pl. 1.— Longitudinal section of a young larva about six days old. The silk glands have not yet become much convoluted. × 37.5.

Fig. 3, pl. 1.— Mature larva showing the enormous increase in the size of the silk glands (*s. g.*). × 12.5.

Fig. 4, pl. 1.— Longitudinal section of a mature larva. × 12.5.

Fig. 5, pl. 2.— Cross section of a young larva (about one day old) in the thoracic region. × 130.

Fig. 6, pl. 2.— Cross section of a mature larva in the thoracic region. × 37.5.

Fig. 7, pl. 2.— Cross section of a young larva (shortly after hatching) in the abdominal region. × 130.

Fig. 8, pl. 2.— Cross section of a mature larva in the abdominal region. × 37.5.

Fig. 9, pl. 1.— Cross section of the posterior end of one of the tubes of the abdominal division of the silk glands. From a larva just hatched. × 267.5.

Fig. 10, pl. 1.— Cross section of the same portion of the gland as in Fig. 9 but at a later period of the larval life. × 267.5.

Fig. 11, pl. 1.— Cross section of the same portion as shown in Figs. 9 and 10 but from a mature larva. × 267.5.

Fig. 12, pl. 1.— Section of a portion of the glandular wall of the abdominal division showing presence of vacuoles (v) and radiating trabeculae in the cytoplasm. × 260.

Figs. 13, 14, and 15, pl. 2.— Cross sections of the third thoracic portion at different periods of the larval life; Fig. 13 shortly after hatching, Fig. 14 at a later period, Fig. 15 from a mature larva. × 267 5.

Fig. 16, pl. 2.— Section of a portion of the 3rd thoracic division showing numerous vacuoles (*v*) near the periphery of the cells. From an immature larva. × 260.

Fig. 17, pl. 2.— Section of portion of the 3rd thoracic division in a mature larva, showing the great thinning of the glandular walls. × 260.

Fig. 18, pl. 1.— Cross section in the region of the 2nd thoracic portion. From a larva about two days old. × 260.

Fig. 19, pl. 1.— Cross section of the 2nd thoracic portion from a nearly mature larva. × 260.

Fig. 20, pl. 1.— Section of a portion of the 2nd thoracic portion, showing numerous vacuoles (*v*) near the periphery of the cells. × 260.

Fig. 21, pl. 1.— Union of the 2nd and 3rd thoracic divisions. × 260.

Fig. 22, pl. 1.— Surface view of the cells of the 2nd thoracic portion. × 260.

Fig. 23, pl. 1.— Cross section of the 1st thoracic division immediately behind the conducting portion. × 260.

Fig. 24, pl. 3.— Longitudinal section of the point of union of the 1st and 2nd thoracic portions. × 267.5.

Fig. 25, pl. 3.— Cross section of one of the conducting branches. × 260.

Fig. 26, pl. 3.— Cross section of the common duct just behind the press. × 260.

Fig. 27, pl. 3.— Cross section of the press, showing the muscular attachment; *d. m.*, dorsal muscles; *v. m.*, ventral muscles. × 260.

Fig. 28, pl. 3.— Longitudinal section of the press, showing the position of the dorsal and ventral muscles, *s. t.*, silk thread passing through the press to the spinneret. × 260.

Fig. 29, pl. 3.— Same as Fig. 28, but showing the attachment of the muscles directly to the chitin of the conducting tube. × 267.5.

Fig. 30, pl. 3.— Longitudinal section of the press, of one of the conducting branches, and of the beginning of the 1st thoracic portion. *a.*, point of union with the conducting branch of the opposite side. × 267.5.

Fig. 31, pl. 3.— Surface view of a cell and its nucleus, from the abdominal portion. From a larva nearly four days old. × 260.

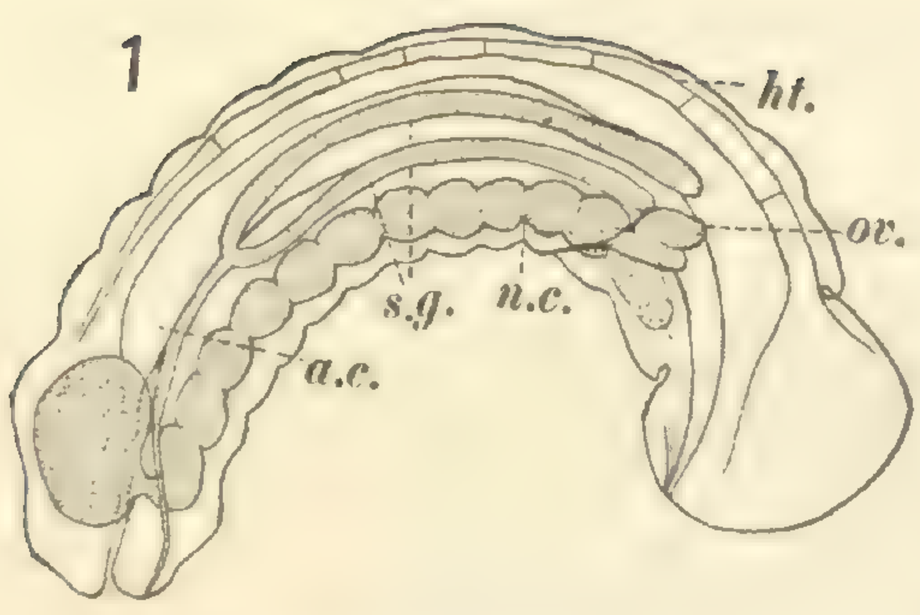
Fig. 32, pl. 3.— Surface view of a cell and its nucleus, from the anterior end of the 2nd thoracic portion of a mature larva. × 260.

Fig. 33, pl. 3.— Surface view of a cell and its branching nucleus, from the posterior portion of the 3rd thoracic division of a mature larva. × 260.

Fig. 34, pl. 3.— Portion of a cell and its nucleus, from the abdominal division of the glands of a nearly mature larva. × 260.

List of Abbreviations

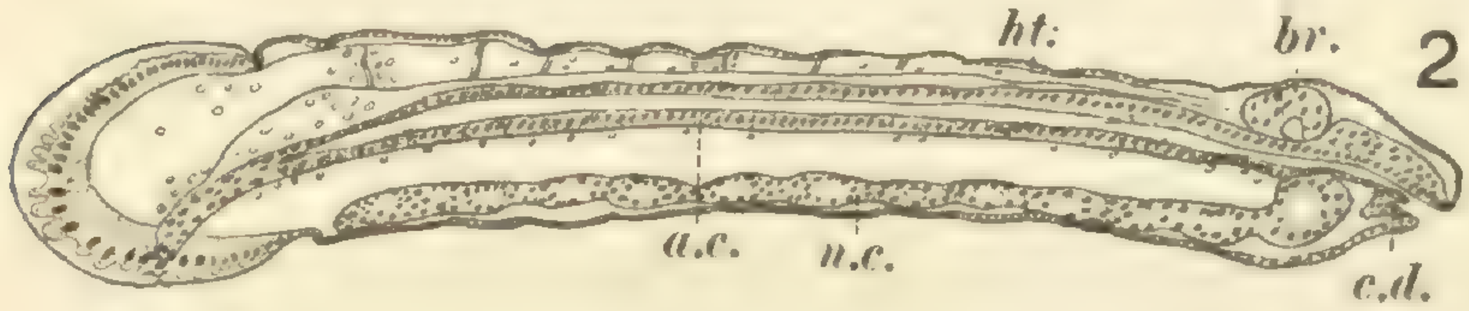
a. c., alimentary canal.
b. c., buccal cavity.
b. m., basement membrane.
br., brain.
c. d., common conducting tube.
ch., chitin.
co. l., cortical layer.
d. m., dorsal muscle.
e. d., conducting tube.
f. b., fat body.
gr., "gres" or "gum."
ht., heart.
in., intima.
int., intestine.
hyp., hypodermis.
l., lumen.
m., muscle.
m. t., Malpighian tube.
n. c., nerve cord.
nu., nucleus.
ov., ovary.
pr., press.
s., silk.
s. g., silk gland.
sp., spinneret.
s. t., silk thread.
tr., trachea.
v., vacuole.
v. m., ventral muscle.
1st. t., 1st or anterior thoracic.
2nd. t., 2nd or middle thoracic.
3rd. t., 3rd or posterior thoracic.

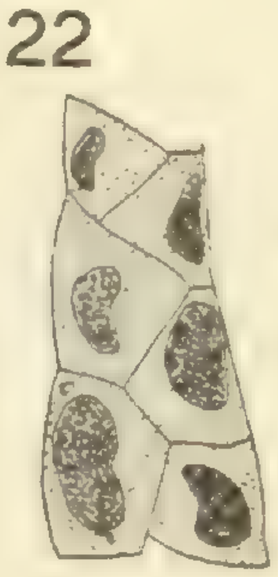

1
ht.
ov.
s.g.
n.c.
a.c.

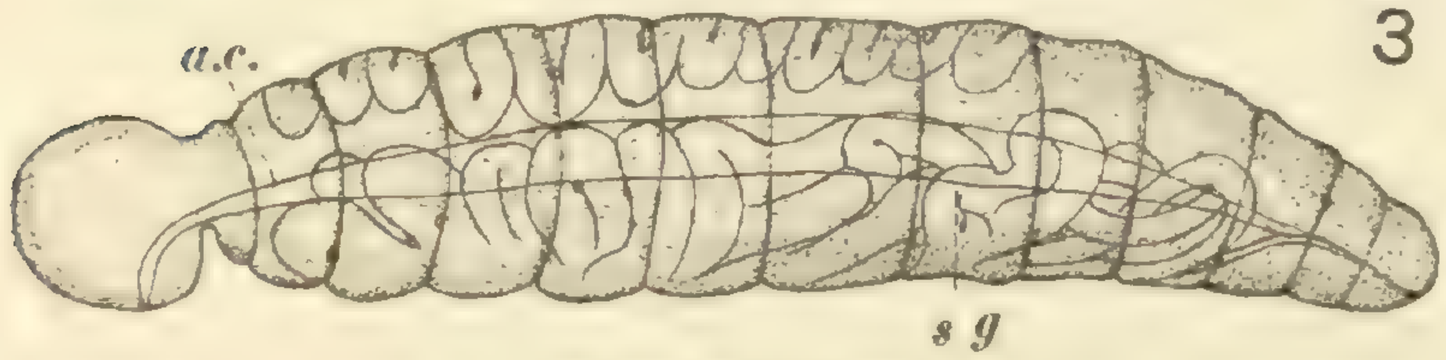
18
l.
19
r
b.m.
gr.

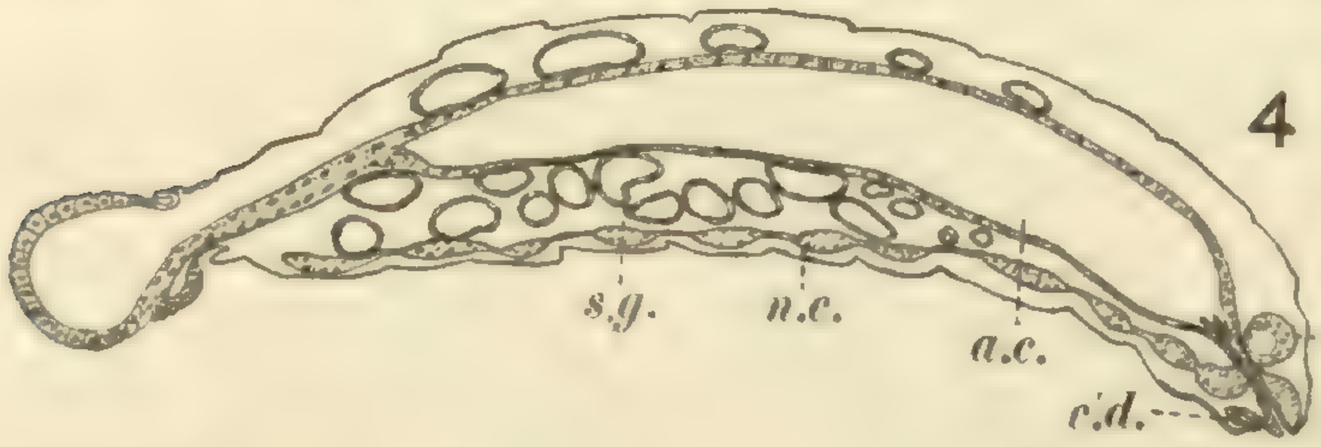
gr.
20
b.m.
s.
r

21
gr.
3rd.t.
b.m.
2nd.t.
gr.

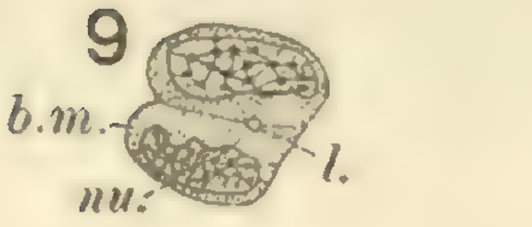

ht.
br.
2
a.c.
n.c.
c.d.

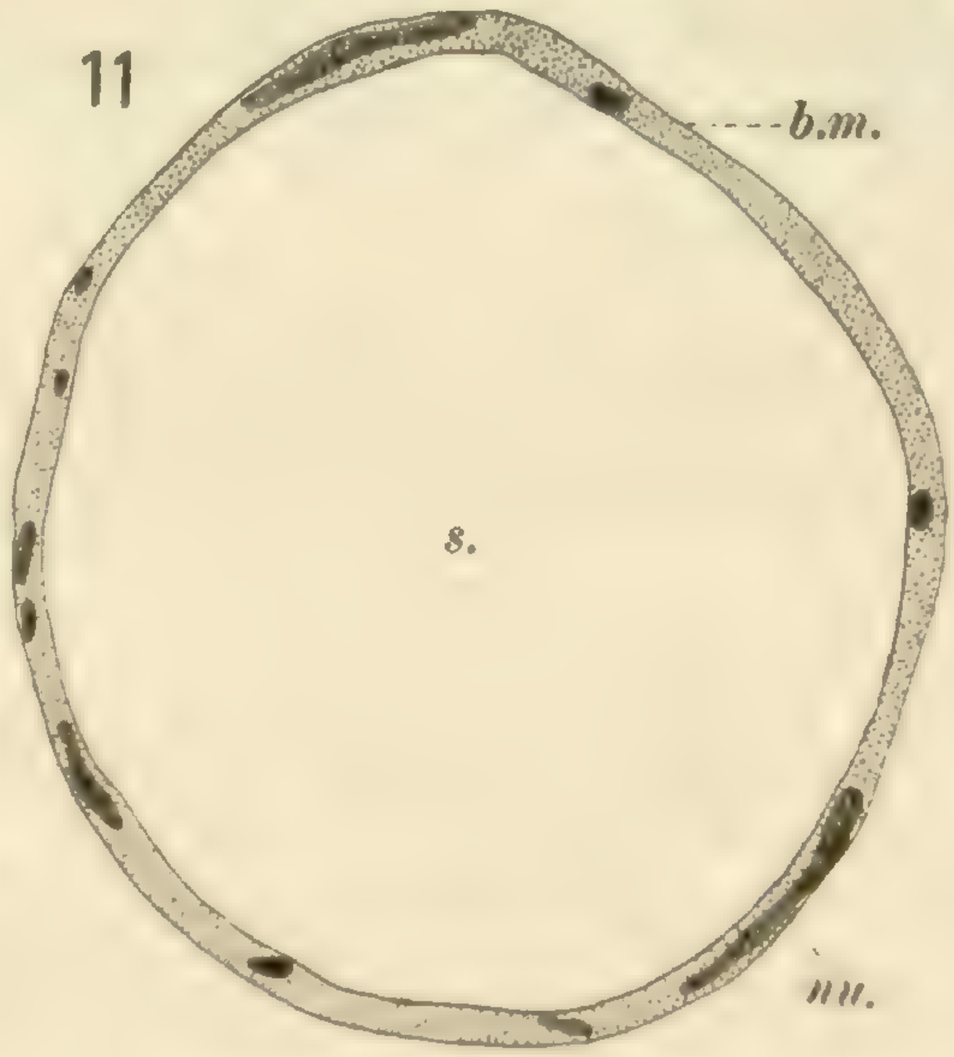

22

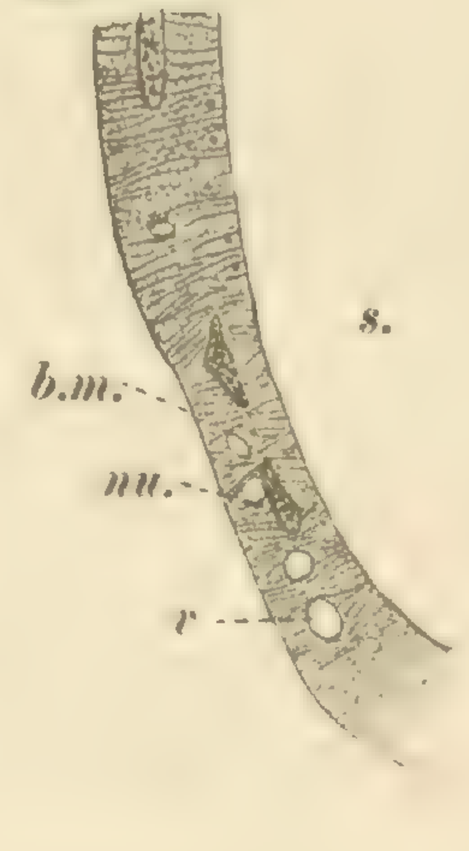

a.c.
3
s g


4
s.g.
n.c.
a.c.
br.
c.d.

23
b.m.
r.
gr.
nu.


9
b.m.
l.
nu.


11
b.m.
s.
nu.


12
s.
b.m.
nu.
r

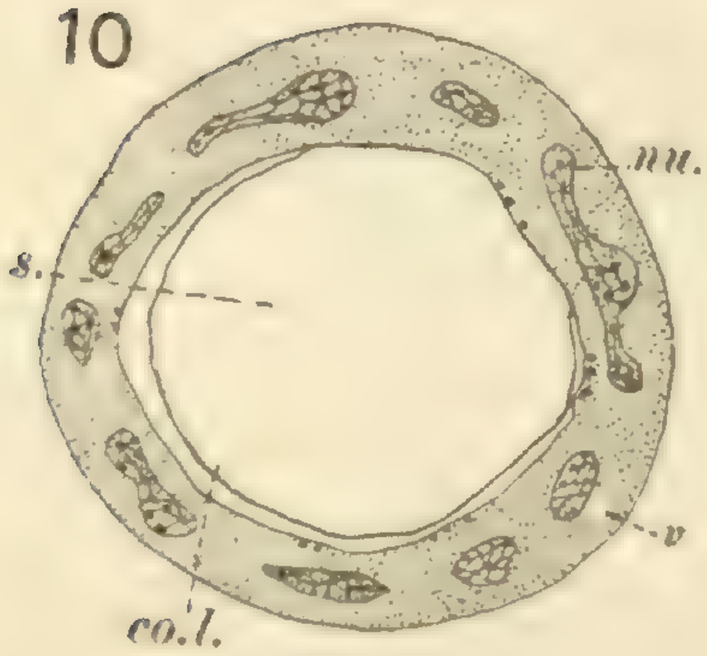
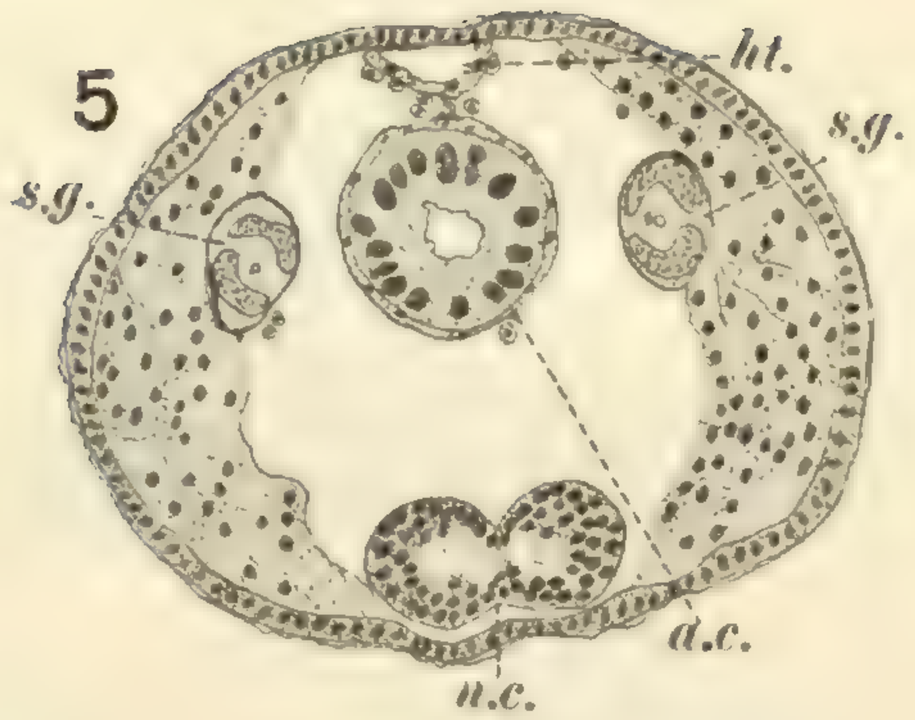
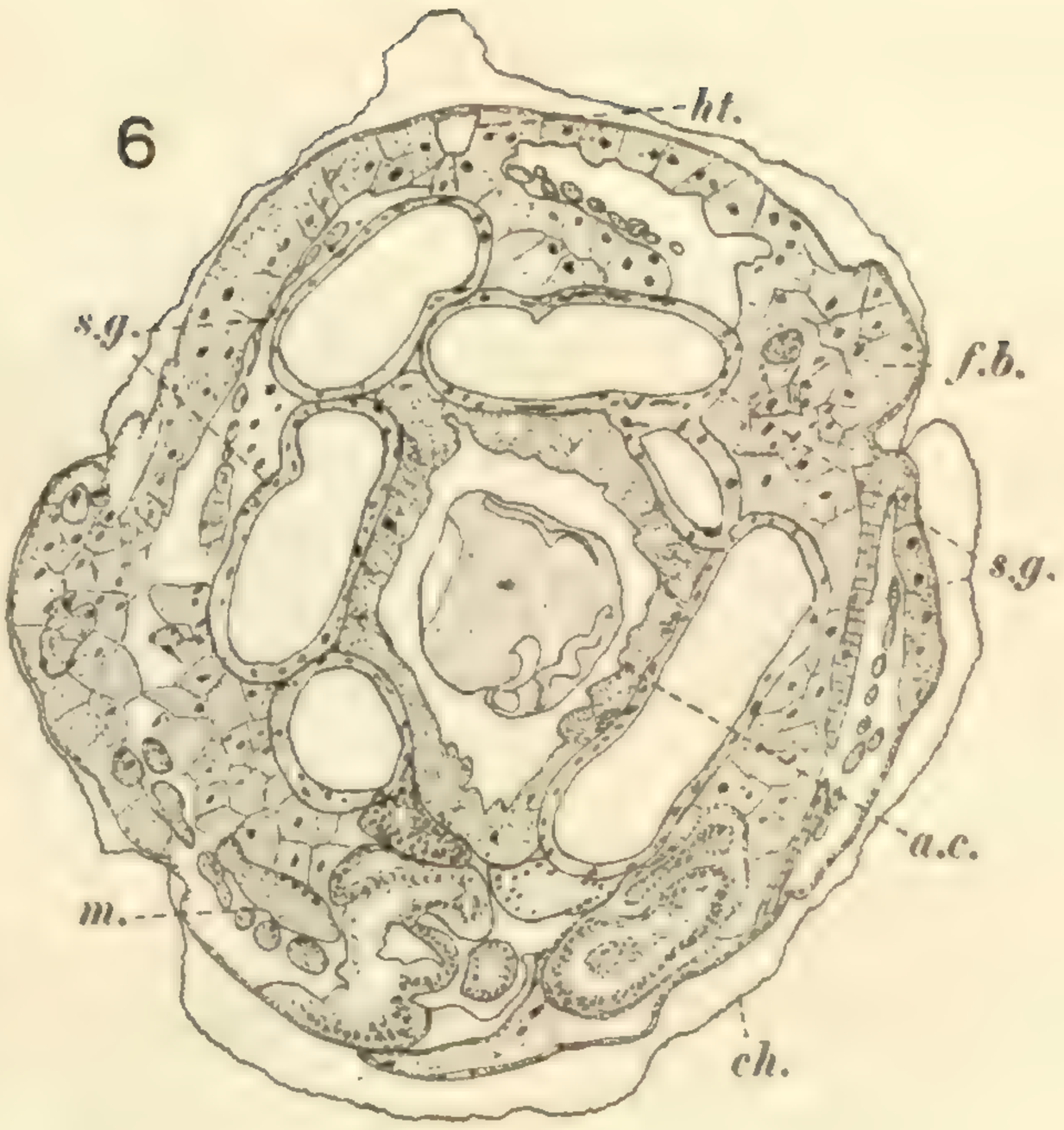

10
nu.
s.
v
co.l.

PLATE 1

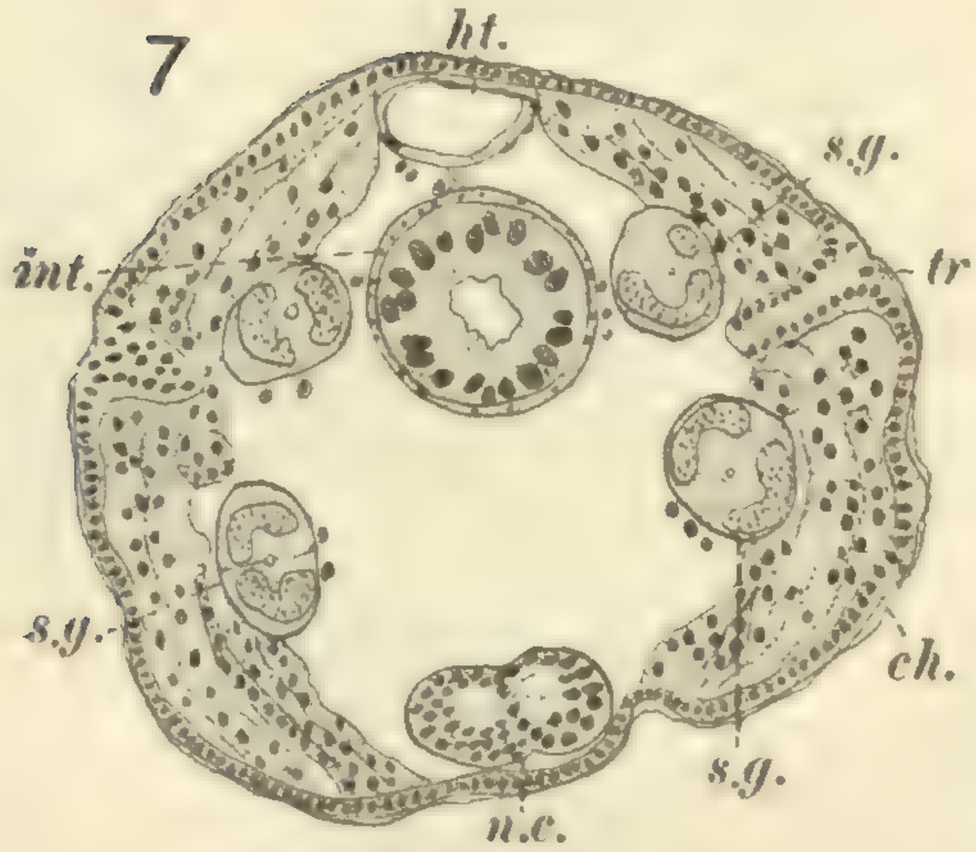
5



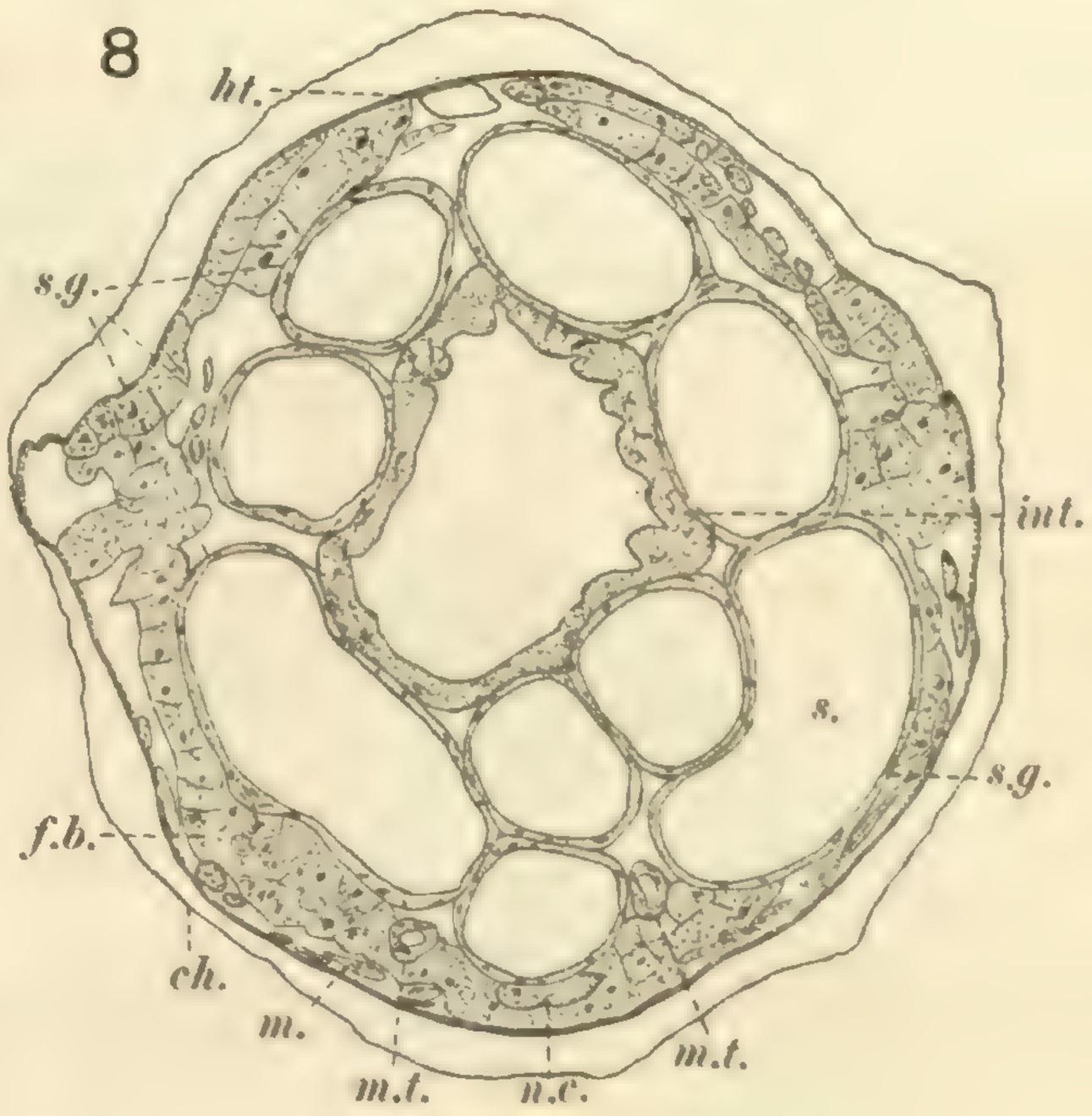
6



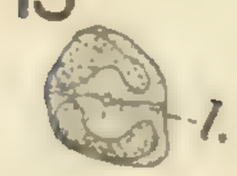
7



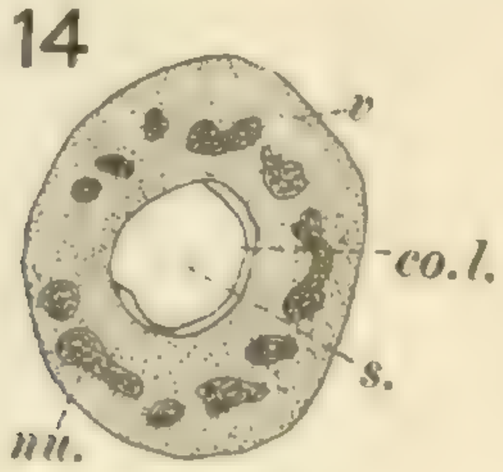
8



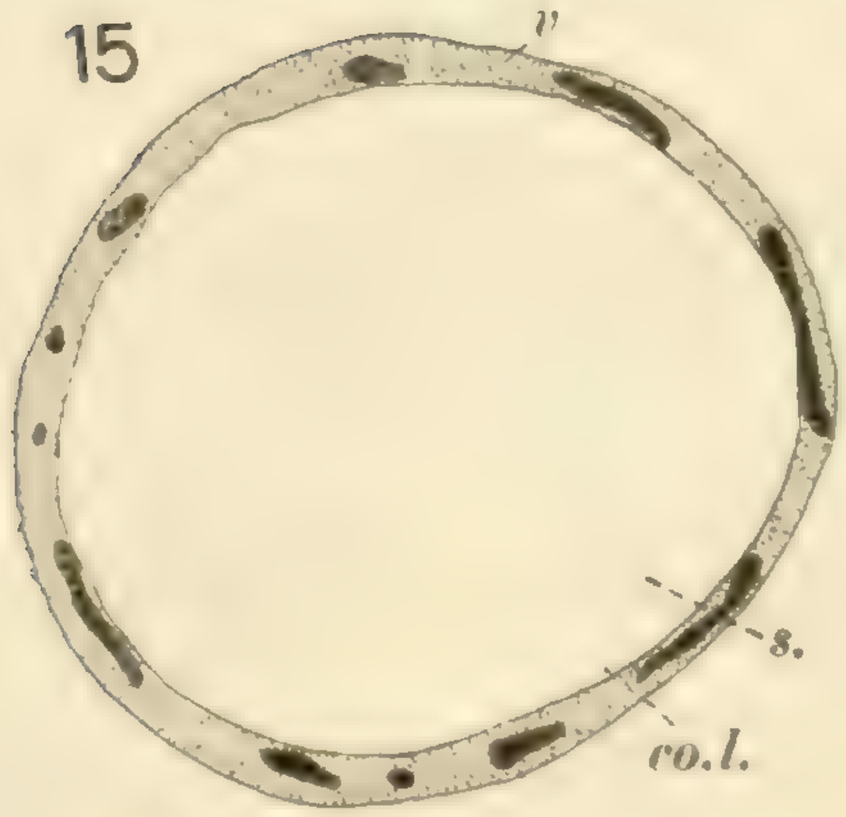
13



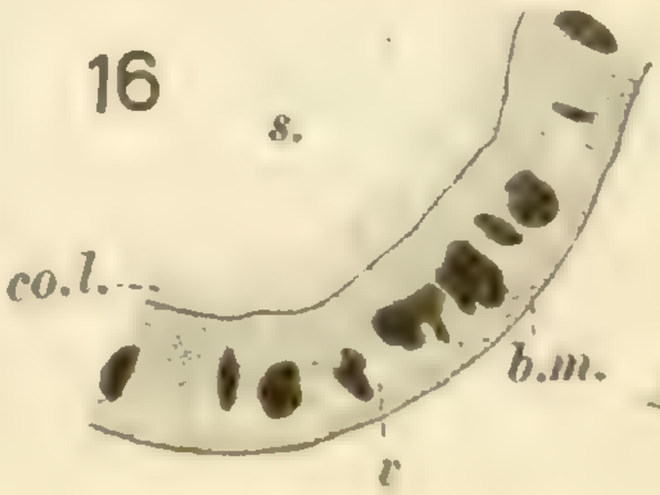
14



15



16



17

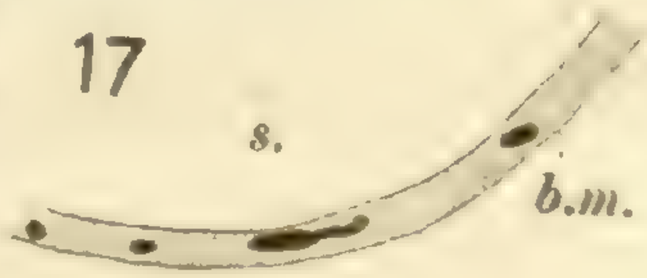
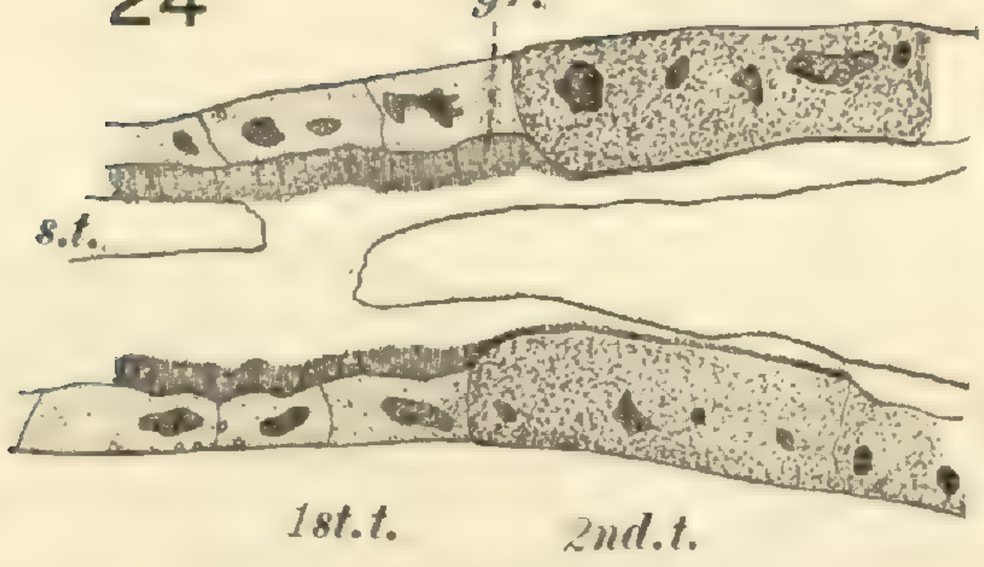
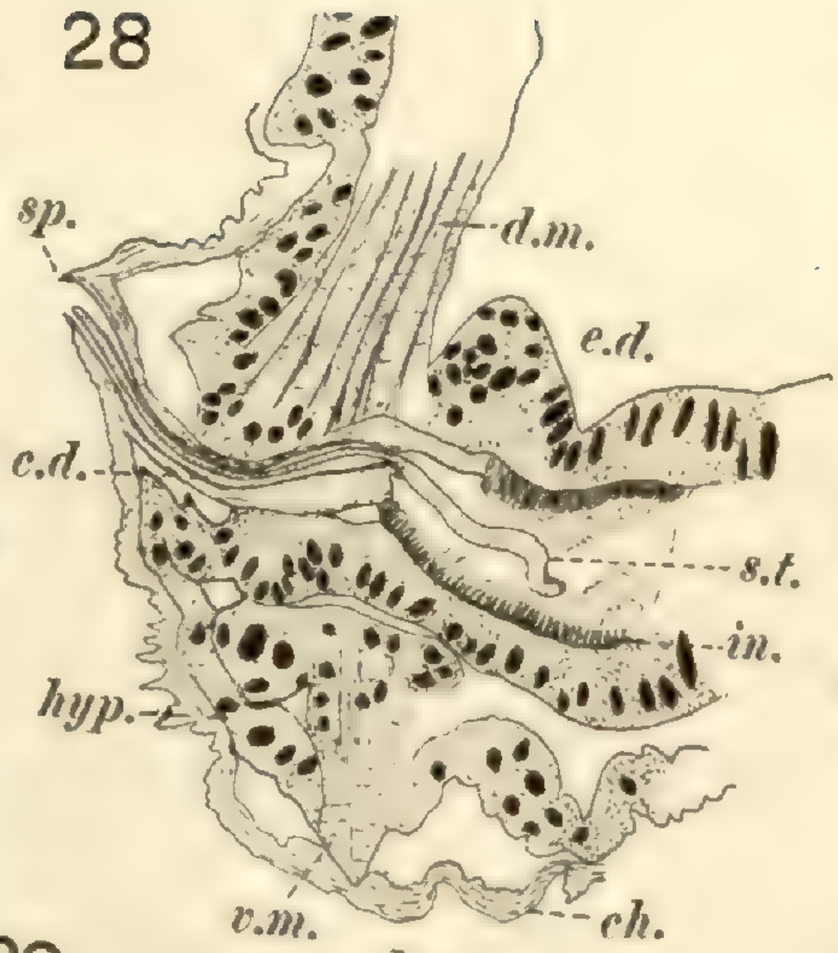


PLATE 2

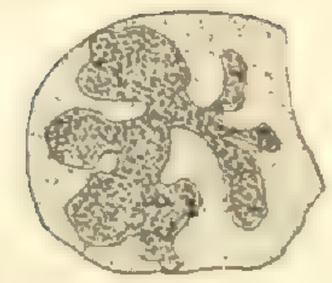
24



28

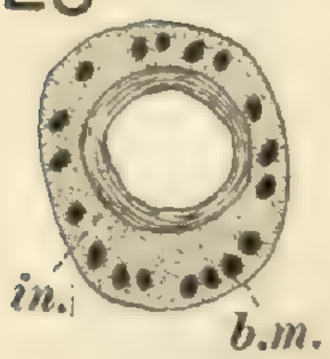


31



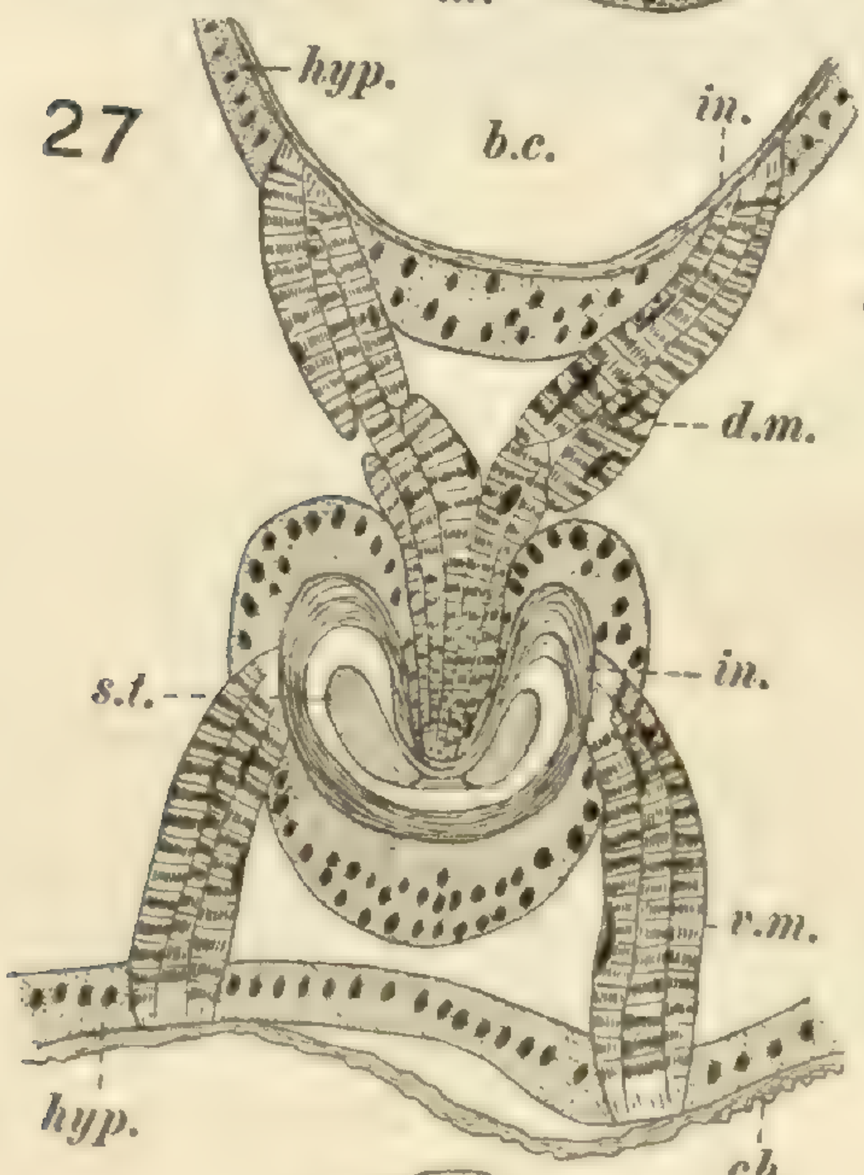
32

25



26

27



29

33

30

34

PLATE 3

THE NEST OF THE KELP FISH

CHARLES F. HOLDER

One of the most interesting fishes found in the great kelp beds along the shores of Southern California is the so-called kelp fish, *Heterostichus rostrata* Girard. In color it closely resembles the sea weed in which it habitually lives. During the past year two adult kelp fishes and a smaller fish of another kind occupied one of the tanks in the Santa Catalina Island Aquarium. The larger kelp fish, a female, was about nine inches in length; the male measured about five inches. I was attracted to them by the savage attacks of the male on the stranger, and investigation showed that he was in nuptial colors and was attending the female. The offending fish was removed giving the kelp fishes the entire tank.

All the colors of the male kelp fish were highly accentuated and brilliant. What had been white was now lavender and silver; the dark angles of the zig-zag barring took on darker tints and were emphasized by countless lines of lavender, yellow, blue and gold; patches of silver, old rose, lavender and white appeared here and there the entire length of the fish, making it a most gorgeous creature. The long vibrating dorsal fin was erect, and the fish was unusually alert as if sensible of the importance of the situation and its responsibilities.

In the tank were several small bunches of a deep maroon seaweed four or five inches high; and as I watched the female, large and heavy with spawn, she approached the weed and appeared to examine it, passing around it several times. Then I saw that her ventral surface was pressed against the weed and that its branches were being caught together by a viscid pure white cord having the diameter of a thick thread. It clung tenaciously to every branch it touched. Along the cord were large numbers of small eggs. When four or five inches of the cord had been attached, the fish would rest, the male taking her place and hovering over the eggs which he guarded with a viciousness altogether unexpected in so small a fish. He withdrew when his mate resumed egg-laying.

She frequently pushed her way through the clump of weed but more often passed around it, the silken tenacious cord binding it together in a globular or oval mass about the size of a hen's egg. The entire nest shown in the photograph was formed in about two hours, the fish dropping to the bottom of the tank after each effort and lying there for ten or twenty minutes.

The accompanying photograph of probably the first nest of Heterostichus to be recorded was made under my direction by

Charles Ironmonger, of Avalon, Cal. It was necessarily taken under cover and through glass and water, all efforts being directed toward having the nest in focus. The head of the female fish shows indistinctly below. Although the photograph was so successful that the eggs within the strands could easily be seen with a hand lens, there was no indication of the beauty of the pure white nest among the rich purple and lavender weeds.

Pasadena, Cal.

NOTES AND LITERATURE

GENERAL BIOLOGY

Specific Characters in Early Embryos.— In a recent contribution to the *Naturalist* it is asked if "by and by we are going to find specific characters in the eggs of animals as well as in their adult condition." In the seventeenth century this was believed to be true, since the egg was supposed to contain in miniature the adult form to which it should give rise. Early in the nineteenth century, however, it was thought that the embryos of the higher animals passed successively through stages corresponding with the adults of lower forms. With the theory of evolution, it began to be considered that the early embryos in different groups of animals were identical and that specific characters were late acquisitions. A few interesting expressions of this opinion are as follows:

"Embryology has revealed the strange resemblance which exists, at the beginning of their formation, between the embryos of different vertebrates; it has shown how each embryo before taking its final form hesitates, so to speak, between different specific forms."[1]

"Take, for example, the case of the highest organism, Man .... When his animality becomes established, he exhibits the fundamental anatomical qualities which characterize such lowly animals as polyps and jelly fish. And even when he is marked off as a vertebrate it cannot be said whether he is to be a fish, a reptile, a bird, or a beast. Later it becomes evident that he is to be a mammal; but not till later can it be said to which order of mammals he belongs."[2]

"The embryo of a mammal at the stage which represents a gill-bearing vertebrate, in all cases which I have examined, ranges from one third of an inch to an inch in length; the former size belongs to the smaller kinds, the latter to the larger. Know one, know all; one diagram would represent all, one description serve for all."[3]

"The careful investigation and comparison of embryos of man and

[1] Cresson, A. Les bases de la philosophie naturaliste. Paris, Félix Alcan, 1907. p. 64.

[2] Romanes, G. J. Darwin, and after Darwin. Chicago, Open Court Publ. Co., 1892. p. 119.

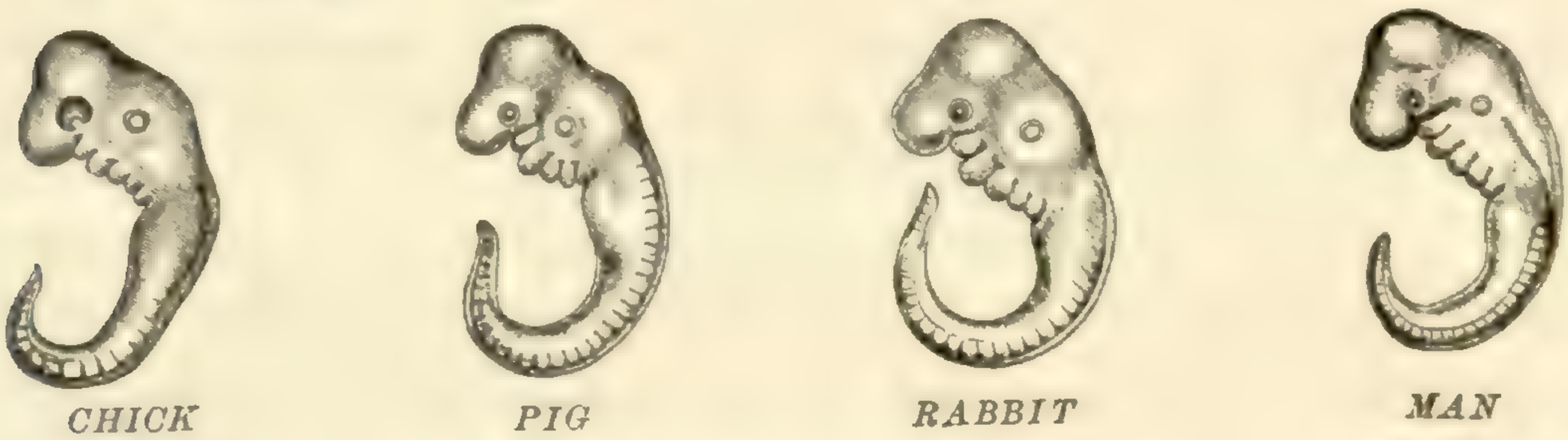
[3] Parker, W. K. On mammalian descent. London, Charles Griffin Co., 1885. p. 14–15.

other vertebrates . . . .is highly instructive and discloses to the thoughtful person deeper and weightier secrets than are to be found in the so-called "revelations" of all the religions of the earth. Compare attentively the successive stages of the chick, pig, rabbit, and man shown in the accompanying figure. In the first stage (the upper row), in which the head with the five cerebral vesicles and the gill arches are clearly marked out but the limbs are still wholly absent, the embryos of all vertebrates from fishes to man differ from one another either unessentially or not at all. In the second stage (the lower row), in which the limbs have begun to develop, distinctions between the embryos of lower and higher vertebrates have begun to appear; yet the human embryo even now is scarcely to be distinguished from those of the higher mammals . . . .These are facts the significance of which cannot be overestimated."[1]

As drawings of embryos, the well known figures of Haeckel here reproduced are totally valueless. The front limbs have been transferred to the neck, and the characteristic features by which any one familiar with embryos can distinguish a pig from a rabbit have been wholly overlooked. Although Parker declared that 'one diagram would represent all,' his figure of the embryo mole could not possibly be mistaken for a pig. Moreover the pig at this stage could be distinguished from the rabbit or man by its pancreas alone. The comparative study of embryos to detect generic and specific differences has not been carried far, but from such publications as Keibel's *Normentafeln* of the pig and rabbit it is evident that at no stage in their development is there a confusing similarity in external form.

In place of Haeckel's upper row of figures, those of still younger stages may be substituted, in which the differences are more obvious. The spherical yolk of the hen's egg, the elongated vesicle of the sheep (that of the pig being quite as long but not so slender), the round smooth vesicle of the rabbit and the villous human vesicle are radically different from each other. Since these membranous structures are parts of the embryo they must be regarded as expressions of differences existing at an early stage. Since a given egg cell can produce only one species of animal it must, according to current embryological belief, contain specific characteristics, and if an inheritable peculiarity appears in any adult animal it will modify to some extent the egg cell and every succeeding stage of development. Thus, according to

[1] Haeckel, E. Anthropogenie. 3rd ed. Leipzig, W. Engelmann, 1877, p. 288–289.



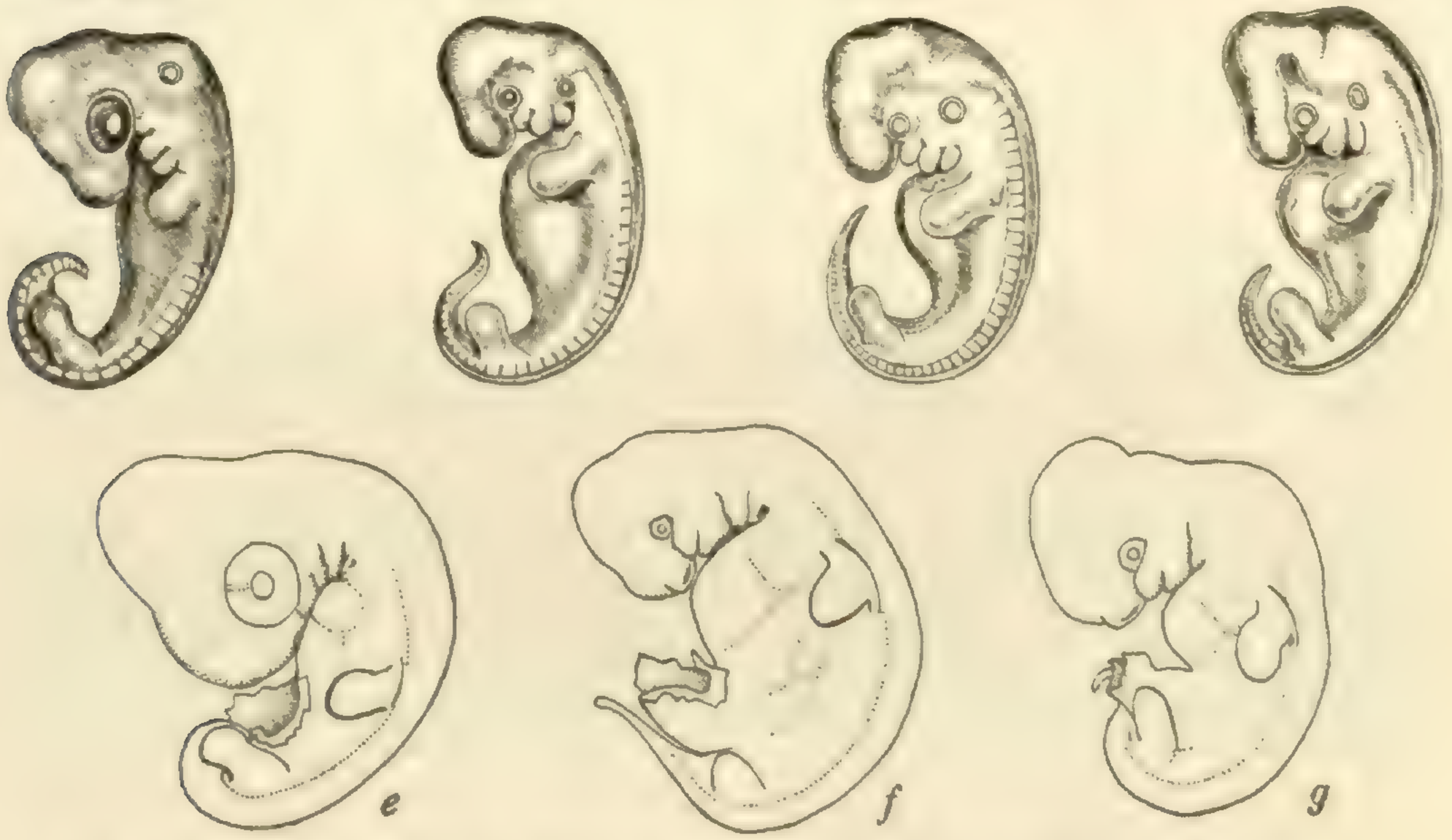


FIG. 1.— The two rows of embryos of the chick, pig, rabbit, and man are from Romanes' copy of Haeckel's figures. The others are:— *a*, sheep, 12 days $2\frac{1}{4}$ hours, $\frac{2}{3}$ nat. size (Bonnet); *b*, chick, 33 hours incubation, $\frac{2}{3}$ nat. size; *c*, rabbit, 7 days, × 2; *d*, man, 12–13 days × 2 (Reichert); *e*, chick, 5 days, 8.5 mm.: *f*, pig, 20 days, (?), 9.0 mm.; *g*, rabbit, $12\frac{1}{2}$ days, 8.5 mm.

Hertwig, there are as many kinds of egg cells as there are species or kinds of animals or plants. Morgan, after an interesting historical consideration of the question, says,— "I should not expect to find the embryos of any two species identical at any stage in their development, but at most there might be a close resemblance between them."[1]

[1] Morgan, T. H. Evolution and adaptation. New York, The Macmillan Co., 1903, p. 74.

Montgomery states that two species are as distinct in the egg-cell stage as in any later one, "no matter whether the differences are as perceptible or not."[1] Such a statement, however, evades the question whether or not embryos of related species can actually be distinguished from one another.

The four suborders of rodents, represented by the squirrel, mouse, guinea pig, and rabbit respectively, according to Lee may be distinguished at very early stages. His studies do not enable him as yet to recognize the genera of one suborder,— namely the gophers, prairie dogs, squirrels, and chipmunks — until the embryos are far advanced. Differences in tunicate eggs of closely related genera have, however, been recorded by Conklin, and McClung can distinguish several species in one genus of grasshoppers by the chromosomes of their germ cells.

F. T. L.

ZOOLOGY

New Text Books of Zoology.— The most important service that biology can render to students is to train their reason and their power of observation, and to free them from a too deep reverence for authority. This service can also be performed by the other natural sciences, physics and chemistry, which are commonly included in the curricula of high schools but which require expensive apparatus beyond the reach of many schools. Biology, however, can be profitably taught with so slight an equipment that every school can afford to undertake to teach botany or zoology, or both. The teaching of biology has often failed to yield the results that educators have expected. This is so because teachers too often yield to the temptation to tell the students the facts and theories which they ought to learn by their own efforts, instead of teaching them how to discover, to classify, and to draw proper conclusions.

Professor Glenn W. Herrick, of the Mississippi Agricultural College has endeavored to meet the needs of the high school of limited means whose students will, as a whole, have no further instruction in biology. He presents to such students a laboratory guide containing directions for the examination (we can scarcely say for the dissection) of some-

[1] Montgomery, T. H. The analysis of racial descent in animals. New York, Henry Holt and Co., 1906. p. 192.

thing more than twenty species of vertebrates and invertebrates, together with questions, the majority of which appear to be answered by the context, the remainder by the companion text book.[1] This method seems to us unwise and the book is apparently less useful than Kingsley's *Elements of Comparative Zoology* (2nd. ed., Henry Holt and Co., 1904). The latter is a cheaper book which gives facts that are otherwise inaccessible to the student and asks questions which can be answered without appeal to costly apparatus, about easily obtained and inexpensive animals. The answers, the student must gather while learning both to find and arrange facts and to draw right conclusions. A more extensive work is that of Linville and Kelly; their *Text Book in General Zoology* and *Guide for Laboratory and Field Work in Zoology* (Ginn. and Co., 1906) give facts and suggestions, especially for the reading of original articles, together with necessary deductions; and ask most interesting and suggestive questions which the student must answer from his own work. The conscientious use of any of these books will give the student about the same facts, but Kingsley, and Linville and Kelly, compel the student so far as a book can do so, to observe and think, which is the most desirable service to the memory-laden youth. It really makes little difference how many facts are given to a student, whatever his future may be; the method of study is of primary importance.

Some of Professor Herrick's diagrams are not wholly correct. For example Fig. 70, which is very much like the excellent figure of a male crayfish in McMurrich's *Invertebrate Morphology* (Fig. 168), is labelled as a female. It is the sperm duct, and not the oviduct as in Herrick's figure, which opens at the base of the last thoracic limb. The following statement from page 33 of the text book is an example of defective fact and theory,— "It may seem strange that the oldest animals (Protozoa) are the simplest, but it is true. It is probably due to the fact that these animals have always lived in the water and the water is probably not very different today from what it was ages ago. Hence there has been nothing to bring about change in these animals, and they have remained much the same." It is needless to say that Protozoa or even Amoebae are not confined to the water and that very many highly developed animals have been evolved in water.

For more advanced students Dr. Gilman A. Drew, Professor of

[1] Herrick, G. W. *Laboratory Exercises in General Zoology*. New York, American Book Company, 1907. 12mo., 110 pp. 60 cents.

Herrick, G. W. *Text Book in General Zoology*. New York, American Book Company, 1907. 12mo., 386 pp. $1.20.

Biology at the University of Maine, has written a *Laboratory Manual of Invertebrate Zoology*.[1] This book is essentially like Bumpus' *Laboratory Course in Invertebrate Zoology*, the first edition of which appeared fifteen years ago, and both are the result of the teaching of zoology at the Marine Biological Laboratory at Woods Hole. The later book, however, differs from the earlier in the addition of tables of classification, an index and a glossary, as well as in the number and length of the directions for dissection.

The second edition of Bumpus' book (1893) gives directions for the dissection of 31 species in 141 pages, while Drew deals with 90 species in 174 pages or, if we exclude the 16 pages devoted to classification, in 158 pages.

This large increase in the number of species without a corresponding increase in the size of the book does not indicate superficiality, as might reasonably be inferred, but is due to the desire to show the student something of the range of modifications in structure and of the marvellous adaptation to environment found among invertebrates. A good example of this is seen in the treatment of the annelids. Nereis and Lumbricus are each given a moderately full description: the specialization of the swimming and sensory organs are emphasized in the former; the nephridia, reproductive organs and musculature in the latter. Other genera show budding; the formation of scales, tubes and shells of various form and material; types of gill; and the differentiation of the body into two or three regions. This is really splendid and we hope that our fear is unwarranted that internal anatomy is given too small a place. This fear is in a measure justified by the fact that the coelom of echinoderms is not mentioned, that of mollusks is indicated only by references to the pericardium and, in the squid, to the ovary "inclosed in a capsule from which the oviduct leads."

The wealth of living material demanded by the book ought to limit its use to marine stations or to schools near the ocean. The glossary is not perfect but is useful. The term nephridium is not defined and the excretory organ of molluscs, which is a nephridium, is called in the text a kidney; and the definition of the kidney is,— "Frequently applied to the excretory organ of an invertebrate." The hypophysis is defined as "a ventral projection from the brain of Chordata."

The book has excellent features and in the second edition which will be demanded soon, minor faults will be eliminated. The book

[1] Drew, G. A. *A Laboratory Manual of Invertebrate Zoology*. Philadelphia, W. B. Saunders Co., 1907. 12mo., 201 pp. $1.25.

will probably serve another decade as well as Bumpus' book has served students of zoology for the past ten years.

LEONARD W. WILLIAMS

Books of Nature Study.— The American Book Company is issuing a series of "Eclectic Readers" for lower grammar school grades. These include *The Trail to the Woods*[1] by Clarence Hawkes, and *Half Hours with Mammals*,[2] by Charles F. Holder. The former is chiefly a collection of hunting stories. It tells of foxes who "stop a moment to consider" and who have learned to place a wounded foot in cold water "to draw out fever and pain." With the humanizing of the foxes there is a cold-blooded account of their destruction — "As the club said, 'They were just old enough to play nicely.' By seven o'clock the pelts of two of them were dangling from the pockets of lucky hunters." This is not good reading for children.

The book by Dr. Holder in some respects suggests Wood's Natural History. It is intended for intermediate grades. The student is advised not to accept the reports of "honest men and women" who impart to animals such traits as "would astonish the bear, fox and others could they read the English language"; but the author states that animal intelligence differs from human intelligence only in degree. His frequent references to his own observations, particularly of Californian animals, form a considerable part of the book. Of the gopher he says,— "I have seen my favorite carnations waving wildly as though an earthquake was shaking them. Then the stalk and flower would disappear, being hauled down into the burrow and eaten." The Reader is fully and attractively illustrated.

Pictures from Nature's Garden[3] is an English book comparable with Bigelow's *Spirit of Nature Study*. It contains reminiscences and stories about children and butterflies, the author being very fond of both. Several of the photographic illustrations refer to mimicry and protective adaptations, which the reviewer believes are interpreted with the simplicity which led Topsy, as described on page 38, to confound frogs' eggs with tapioca pudding. To justify the child's mistake the author presents a photograph of both. After an interesting descrip-

[1] Hawkes, Clarence. *The Trail to the Woods*. New York, American Book Company, 1907. 12mo, 176 pp., illus.

[2] Holder, Charles F. *Half Hours with Mammals*. New York, American Book Company, 1907. 12mo, 253 pp., illus.

[3] Shepheard-Walwyn, H. W. *Pictures from Nature's Garden*. London, John Long, 1907. 8vo, 311 pp., illus. 6 s.

tion of his butterfly-house, a green-house devoted to rearing plants and insects together, he writes as follows;— "In my younger days I myself amassed an extensive collection of butterflies and moths....I have the collection still, and never look upon it without pride. Friends love to gaze upon the Scarlet Tigers, Clouded Yellows and mammoth Death's Heads; white bearded fossils come down from afar and beam upon it — but when all's said and done what else is it but a collection of corpses? Beautiful though they may be to look upon, arranged systematically with pinions outstretched upon the clean white paper — how much more beautiful to gaze upon the living form flashing its gorgeous wings in sunlight, throbbing with the exuberance of *life*!" This is a frank statement from a collector, but one which is characteristic of the times; interest is being transferred from collections to nature itself.

F. T. L.

Birds of Labrador and of the Chicago Area.— The *Birds of Labrador* are well presented by Dr. Charles W. Townsend and Glover M. Allen (*Proc. of the Boston Soc. of Nat. Hist.*, vol. 33, pp. 277–428). In the introduction the authors describe first their visit to Labrador in the summer of 1906; then the topography, the faunal areas, paths of migration, and ornithological history of the region; and finally the bird and egg destruction which in 1833 filled Audubon with "horror and disgust." "Where fishermen are numerous sea birds are very scarce" and the authors hope that "the wonderful nursery for water birds in Labrador will not be entirely depopulated but that sufficient protection for the breeding birds will be given and that speedily, before it is too late."

The introduction is followed by an annotated list of all Labrador birds, and the book concludes with a table showing the approximate number of each species observed by the authors, a bibliography, and a map. This publication (which is sold separately) will be of interest to the large number of students of local birds in eastern United States, for Labrador is the destination of many familiar migrants. It is unusually well written.

The Birds of the Chicago Area are similarly treated by Frank M. Woodruff (Bull. 6 of the *Nat. Hist. Survey, Chicago Acad. of Sci.*, 221 pp.). The introduction contains notes on the favorable localities for studying birds, their migration, the rapacity of collectors, etc. The catalogue of species brings together a large body of facts covering a long period of observation. Sometimes, however, the list of synonyms

occupies more lines than the account of the bird, as with the savanna sparrow and purple martin. An amusing feature of the extensive bibliography is the translation of the titles of newspaper articles into intelligible form, for example,— *Linger in Winter's Lap.* (An account of birds which delayed their migration.)— *Birds of Mystery at Lake Forest.* (Notes on evening grosbeaks.)— The twelve half-tones of birds or bird haunts include a photograph of a colony of great blue herons, twenty miles north of Chicago.

F. T. L.

The Excess of Male Births.— In the May *Naturalist* (vol. 41, p. 303) A. H. Pike discussed the significance of the excess of male births in human offspring, extensive statistics indicating that 106 males are born for every 100 females. In the June issue of the *Proc. of the Cambridge Phil. Soc.* (vol. 14, p. 122) Walter Heape presents the best available statistics for dogs. Among 36,867 pups of registered stock there are 117 males for every 100 females. Of some twenty breeds considered, all showed an excess of males except two, the figures for which were based on limited returns. The excess of males is apparently greater in large breeds of dogs than in small ones. Mr. Heape believes that the *latest* moment at which sex of offspring can be determined is the time of fertilization. However, since nutrition of the parents may alter the sex-determining factors in their spermatozoa or ova, he thinks it possible that the sex of offspring may be controlled, at least to some extent.

F. T. L.

Recent Publications Concerning the Structure of Insects.— *The Wing Rudiments of the Sheep Tick.*— That the wings of the adult insect are present in the larva in the form of disk-like rudiments is a well known fact. Even wingless species, excepting the Thysanura, possess these so-called "imaginal disks" in the larvae, thus indicating descent from winged ancestors. Extending the work of Pratt, '00, Stange,[1] '07, has traced the development and the degeneration of the rudiments of the wings and halteres in the sheeptick, *Melophagus ovinus.*

He finds that in the earlier stages the disks of the wings and the halteres are identical in appearance except that from the first the

[1] Stange, P. Über die Rückbildung der Flügel und Halterenscheiben bei *Melophagus ovinus*. *Zool. Jahrb. Anat.*, 1907, 24, pp. 295–322. Pls. 27–28.

wing rudiments are the larger. The wings continue to develop until in the late pupal stages they are provided with a chitinous covering bearing bristles. They then degenerate so that there are left in the adult only peg-like vestiges well supplied with nerves, and possibly sensory in function. Previous workers have mistaken these structures for vestiges of the halteres. The latter, however, completely disappear and are replaced by a spiracle.

The Physiology of Metamorphosis.— An important contribution on the subject of the changes which initiate metamorphosis in insects is a brief article by Metalnikoff.[1] Utilizing the method of marking the leucocytes by means of carmine injections he was able to establish beyond question their active participation in the histolytic changes.

The most interesting feature of his work is the discovery that at the beginning of metamorphosis there appear in the blood of the larva specific toxines which apparently poison definite tissues and cells, and thus render them liable to the attacks of the phagocytes. Blood of mature larvae of *Galleria melonella* was injected into young larvae of the same species and led to almost immediate paralysis. For a half hour or longer, depending upon the quantity of blood injected, the subject lay as though dead, and then gradually recovered. Check experiments showed that injection of the blood of young individuals is perfectly innocuous. The toxicity of the blood is manifest two or three days before pupation and disappears about the third day of pupal life, as soon as the course of histolytic change is run, and the building up of new tissues is well under way.

Similar results were obtained from experiments on the silk-worm, but there is brought out the interesting fact that injections of blood of Galleria has no effect on Bombyx and *vice versa*.

Regeneration in Insects.— Przibram[2] has succeeded in the difficult task of rearing to maturity the common European Praying Mantis, and has studied their color variations and their power of regeneration.

He found that this species which in nature is usually green or brown in captivity produced solely brown nymphs and yellow imagos. The number of molts is seven or eight. The color may vary during the nymphal period but this is apparently independent of their surroundings, degree of moisture, or temperature.

[1] Metalnikoff, S. Zur Verwandlung der Insekten. *Biol. Centralbl.*, 1907, 27, pp. 396–405.

[2] Przibram, H. Aufzucht, Farbwechsel, und Regeneration unsrer europäischen Gottesanbeterin (Mantis religiosa L.). *Arch. f. Entwicklungsmechanik*, 1907, 23, pp. 600–614.

The grasping leg is capable of regeneration but on account of the great mortality among the nymphs this is seldom to be observed.

The same investigator, assisted by Werber,[1] has carried on a series of experiments on the power of regeneration in the bristle-tails (Lepismatidae) which on account of the generalized condition of this group are of especial significance.

The authors find that the Lepismatidae show a marked power of regeneration, since antennae, palpi, anal stylets, and legs may be replaced after mutilation. This capability was to be noted even in sexually mature individuals.

In molting, growth phenomena, and power of regeneration the forms studied display a generalized condition in keeping with their low systematic rank, and comparable to what has already been reported for the myriapods and crustaceans.

The Post-embryonic Development of the Mid-intestine in Trichoptera. — The changes undergone by the mid-intestinal epithelium of insects at the time of metamorphosis have been the subject of considerable study during recent years, but in a preliminary paper Russ[2] has brought to light some entirely new facts regarding epithelial replacement in the pupa of the caddice-fly, *Anabolia laevis*.

In the first day of the prepupal stage there begins an active division of the cells in the regenerative centers of the mid-intestine. The new cells extend out under the old larval epithelium which is soon entirely cast off and forms in the lumen of the intestine the so-called larval "yellow body." Meanwhile the new cells have completely clothed the intestine and now through their activity hasten the dissolution of the mass of old tissue.

Thus far the conditions are similar to what have been observed in other insects. The new epithelium, however, does not *in toto* become the definitive lining of the intestine of the adult. By a contraction of the muscles of the mid-intestine and a consequent formation of a ring-like thickening within its lumen its two ends are brought into proximity. The ring of epithelium and muscle is then constricted off, and now forms a second "yellow body" within the definitive mid-intestine which has been formed from only a small portion of the prepupal tissues.

[1] Przibram, H. und E. I. Werber. Regenerationsversuche allgemeinerer Bedeutung bei Borstenschwanzen (Lepismatidae) l. c. pp. 615–631.

[2] Russ, E. Über die postembryonale Entwicklung des Mitteldarmes bei den Trichopteren (*Anabolia laevis* Zett.) *Zool. Anz.*, 1907, 31, pp. 708–710.

The Suboesophageal Body of Insect Embryos.— The question as to the origin and the morphological significance of the suboesophageal body which has been found in certain insect embryos is an open one. Hirschler[1] has studied this structure in embryos of Donacia and has added much to our knowledge of its nature. He finds that it is entodermal in origin and that from an unpaired rudiment at the end of the stomadeal invagination there arise four rounded, paired masses which finally communicate directly with the lumen of the mid-intestine. These persist until at least the third day of larval life,— their further fate has not been studied.

Hirschler's results apparently confirm the theory of Nusbaum and Fulinski, '06, that the suboesophageal body is to be homologized with the hepatopancreas, or glandular diverticula of the mid-intestine, of the Crustacea.

W. A. Riley.

Stridulation Rhythm of Crickets.— According to A. F. Shull (*Can. Ent.*, vol. 39, p. 213), in the chirping of the snowy cricket "exact synchronism is comparatively rare" and exists only between two or three neighboring individuals. Thus two crickets five feet apart were observed to time their chirps in unison as if they heard each other. The rate of stridulation is independent of wing length; in general it increases with rise in temperature, but Dolbear's and Bessey's formulae to express this relation are only approximately correct. Under the same conditions the rate in different individuals varied from 93 to 110 chirps per minute. Except on cool nights, from 600 to 800 chirps are usually performed continuously; one cricket was found to chirp 2,640 times without interruption.

Notes.— Bull. 110 of the N. Y. State Museum, preparatory to a monograph of the Cecidomyiidae, presents descriptions of 203 new species belonging to this group. The Cecidomyiidae, or gall gnats, are dipterous insects from 0.5 to 3.0 mm. in length which produce various leafy galls including the "willow cones." Bull. 109 of the N. Y. State Museum is devoted to the tussock moth and elm leaf beetle, presenting a colored plate of each, and six photographs showing their destructive effects. The gypsy moth and brown tail have not yet invaded New York.

[1] Hirschler, J. Über leberartige Mitteldarmdrusen und ihre embryonale Entwicklung bei Donacia. *Zool. Anz.*, 1907, 31, pp. 766–770.

BOTANY

Plant Geography.— *The Scandinavian flora.* Several naturalists have considered the origin of the biota of the Scandinavian peninsula. During the glacial period most of the higher forms of life must have disappeared, leaving the peninsula to be repopulated by immigrants from other regions as the ice receded. This immigration was early thought to have had two sources: the central European lowlands and the Russo-Siberian region. The biota of the former is supposed to have come in by way of one or more Baltic land connections, and that of the latter is thought to have gained access by way of Finland and northwestern Russia. But besides these a third element, called by Blytt "the Atlantic group" of plants, was discerned, as the flora, especially of the western part, became better known.

This so-called "Altantic" element is discussed by Stejneger (*Smith. Misc. Coll.*, quart. iss., 3:458–513. 1907) from both the zoological and botanical sides. The term "Atlantic" he considers an unfortunate designation for those members of the fauna and flora which occur nowhere in Norway except along the coast between Stavanger and Kristianssund or where they may be shown to have been derived from this secondary center of distribution. This association shows a strong resemblance to the biota of Scotland and northwestern Ireland, and Stejneger thinks that the similarity is not due to parallel development but that it indicates a direct genetic connection between the two. The possibility of the immigration of this element from Scotland across the present expanse of water is considered and the author concludes that in addition to the arguments against this hypothesis offered by plants and lower animals, the presence of mammals offers a finally conclusive proof of a prior land connection between northern Scotland and western Norway. He thinks that certain geological considerations support this theory.

Endemic plants in Ceylon. Willis publishes important contributions to our knowledge of endemism (*Ann. Roy. Bot. Gard. Peradeniya* 3:271–302. 1906; 4:1–15. 1907). Ritigala is an isolated mountain in the north-central province of Ceylon, which, although of no great height, arises abruptly from the plains and forms the highest ground between the central mass of the Ceylon mountain system and the very similar hills of southern India. The nearest hills are forty miles to the

south and the intervening region is dry, and judging from the configuration of the region must always have been so for at least 25 miles of the distance. It is almost rainless except during the season of the eastern monsoon from September to December. The summit of the mountain, however, is bathed in mist and consequently affords an isolated "moist region" vegetation, practically confined to a few acres within 100 vertical feet of the summit which it must have reached by leaping at one bound over the intervening 40 miles of dry lowland that separate it from the Matale hills to the south or over the 280 miles that separate it from the hills of southern India.

A flora of 144 flowering plants and ferns is found at or near the summit. Of these, 41 belong to the dry region and consequently have not had to be transported forty miles to reach the summit. Of the 103 remaining species, 24 have in all probability been introduced by birds; and 49, of which 24 are ferns or lycopods, have evidently been brought by the wind. Thus only 30 remain whose method of introduction is doubtful; these Dr. Willis discusses in detail.

Bearing these facts in mind, we may now turn to the question of endemism. Of the 144 species and varieties of the flora of the summit, 13 are strictly endemic so far as is now known, and 1 other which may perhaps occur in the mountains of southern India, is provisionally added to the list. The distribution of these plants in the groups recognized above is as follows:

	Total	Endemic
Dry Zone Plants	41	1
Carried by Birds	24	1
Carried by Wind	49	3
Doubtful	30	9
	144	14

The conclusion to be drawn from these figures is that: "Endemism, other things being equal, goes in general with difficulty of distribution and with rare arrival at one spot." The author adduces arguments to show that the introduction of seed by birds would be much more common than that by wind, and that the arrival of seed of those forms which have been classed as doubtful would be the least likely of all. A new form arising from a stock which had reached the summit will be less likely to be swamped by crossing with the parent species if the latter arrives very infrequently. Among the dry zone plants the only endemic form belongs to a genus in which the seeds are extremely ill adapted to transportation over long distances. If difficulty of arrival be one of the conditions of endemism, one would expect to find the

greatest number of endemic forms related to species which are rare elsewhere, and this seems to be true in the case of this flora. Indeed it would seem that the endemic forms belong chiefly to families which show the largest number of endemics elsewhere in Ceylon.

In his second paper, Dr. Willis attempts to show that the differentiation of endemic species cannot be due to the action of natural selection on infinitesimal variations. The arguments are:—

The distinguishing characteristics cannot be shown to have any adaptive value. The endemic forms are often associated with the species from which they have probably been derived. They have not supplanted them as they would if evolved by the selection of special adaptations. The distribution of endemics is narrower than that demanded by their environmental conditions, and corresponds rather with that resulting from an origin by mutation.

In conclusion the author remarks:— "The evidence is not so absolutely in favor of mutation as it is against selection of infinitesimal variations, but at present the mutation theory is the only one in the field which can be invoked to explain the facts."

J. Arthur Harris

Lock on Progress in the Study of Variation, Heredity and Evolution.[1] — This attractive little volume contains two introductory chapters on the general conceptions of evolution, one on the theory of natural selection, one on biometry and one on the theory of mutation. The three chapters following these are devoted to a discussion of the results from investigations of hybridization. One of these is essentially an historical sketch of the work of the older hybridists. The two succeeding chapters treat of Mendelism, to the literature of which the author has already made valuable contributions. In chapter ten he discusses the bearing of recent cytological investigations upon the problems of heredity. A final chapter sums up and discusses the general bearing of the subjects treated.

That the author is a mutationist appears from even a casual reading of a few pages. The style is simple and for the most part very clear as are also the diagrams which serve as illustrations. A few excellent half tones, particularly the portraits of Darwin, Galton, DeVries, Kölreuter, and Mendel, add much to the attractiveness of the book. Possibly the author might have found a much more weighty quotation for his closing pages than one from Bernard Shaw.

[1] Lock, R. H. *Recent Progress in the Study of Variation. Heredity and Evolution.* London, John Murry, 1906. xiii + 299 pp.

The work can be regarded only as an introduction to the modern experimental and biometric study of evolution, since much space is devoted to elementary principles, but it is a commendable effort to bring the newer work before a wide circle of readers.

J. A. H.

Notes.— *The origin of the cow-pea* has been investigated by Wight (*U. S. Dept. of Agric., Bur. of Pl. Ind.*, Bull. 102. 1907.) who concludes that this legume is a native of India and the region northwestward to the trans-Caspian district. Its cultivation in that region is very ancient and it also extended to China at an early period. As early as the beginning of the Christian era it was known in Arabia and Asia Minor and was cultivated in at least one of the countries of southern Europe at about the same time. Its introduction into central Europe occurred much later and independently. It seems to have been introduced into the West Indies in the latter half of the seventeenth century and probably reached the mainland during the first half of the eighteenth century.

Statistical Methods.— Elderton[1] has published a small volume treating in detail some of the less generally known biometric methods. Biologists working with the more refined statistical methods will find it very helpful.

The presidential address before the section of Economic Science and Statistics of the British Association (*Rep. Brit. Ass.*, 76: 629–642. York, 1906.) is a plea for scientific method in statistical research. While primarily of interest to students of social problems, statistical biologists will be interested in some of the arguments.

Notes on Economic Botany.— The second volume of the handbook of sugar cane culture and cane sugar manufacture for Java (Handboek ten Dienste van de Suikerriet-Cultuur en de Rietsuiker-Fabricage op Java. Amsterdam. 1906) published by the associated sugar experiment stations of east and west Java, has just appeared. This elegantly illustrated volume is devoted to the animal enemies of the sugar cane and their parasites.

Takeushi (Bull. Coll. Ag. Imp. Univ. Tokyo. 7:465–468. 1907) discusses the chemical composition of the shoots of *Aralia cordata*,

[1] Elderton, W. P. Frequency Curves and Correlation. 1907. London. Charles and Edwin Layton. xiii + 172 pp.

extensively used as food in Japan and now being introduced into the United States. Funatsu (*l. c.*, 469) gives the composition of a chrysanthemum flower used as food. Albahary (Compt. Rend., 145:131–133. 1907) publishes analyses of the fruit of the tomato. Jaffa (Yearb. U. S. Dep. Ag. 1906; 295–312. 1907) considers the value of nuts as food.

Ybarra (Smith. Misc. Coll., quart. iss. 3:428–457. 1907) has done a service to those interested in the natural history of America by publishing an annotated translation of a letter by Dr. Diego Alvarez Chanca, physician to the fleet of Columbus, dated 1494, relating to the second voyage of Columbus. The letter embraces observations made between November 4, 1493, and the last week in January 1494. Of course but little space could be devoted to botanical matters but several of the references to economic plants are of considerable interest.

J. A. H.

The difficulties of botanists in capitalizing specific names are illustrated in "The Flora of the Gulf Biologic Station," recently issued by the Louisiana Board of Agriculture. It refers to *Verbesina Virginica*, *Commelina virginica*, *Lycium Vulgare*, *Eleocharis Mutata*, *etc.* *Cassia Chamaecrista* of Gray's Manual is written *Cassia chamaecrista*. *Ipomoea pes-caprae* may be compared with *Panicum Crus-galli*. Uniform decapitalization would prevent such confusion. This "Flora," which records some twenty-six phanerogams not previously reported in Louisiana — a state which "is to-day almost unknown botanically" — is to be supplemented by further publications. Its author, R. S. Cocks, refrains from naming prematurely several new forms.

PUBLICATIONS RECEIVED

From July 1 to August 1, regular exchanges not included
The year of publication, when not otherwise noted, is 1907

DREW, G. A. *A Laboratory Manual of Invertebrate Zoology.* Philadelphia and London, W. B. Saunders Company, 1907. 12mo, 201 pp. $1.25.— HERRICK, G. W. *Laboratory Exercises in General Zoology.* New York, American Book Company, 1907. 12mo, 110 pp. 60 cents.— HERRICK, G. W. *Text-Book in General Zoology.* New York, American Book Company, 1907. 12mo, 386 pp. $1.20.

BANKS, N. A catalogue of the Acarina, or mites, of the United States. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 595–625.— DANIELS, F. P. The flora of Columbia Missouri and vicinity. *Univ. of Missouri Studies*, sci. ser., vol. 1, no. 2, 318 pp., pl. 1.— FISHER, W. K. The holothurians of the Hawaiian Islands. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 637–744, pls. 66–82. GIDLEY, J. W. A new horned rodent from the Miocene of Kansas. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 627–636, pls. 58–65.— GUZMAN, D. J. La enfermedad del café en el Salvador. *Com. Parasitol. Agric.*, circ. 60, 24 pp., 6 pls.— INDA, J. R. El gorgojo de las Semillas. *Com. Parasitol. Agric.*, circ. 59, 21 pp., 8 figs.— INDA, J. R. El gorgojo de los plantios de Chile, llamado Barrenillo. *Com. Parasitol. Agric.*, circ. 58, 11 pp., 5 figs.— LYON, M. W. Notes on the porcupines of the Malay Peninsula and Archipelago. *Proc. U. S. Nat. Mus.*, vol. 32, pp. 575–594, pls. 54–57.— MORTON, G. E. Ration experiments with lambs. *Wyo. Exp. Sta.*, bull. 73, 18 pp., 12 figs.— NEWLAND, D. H. The mining and quarry industry of New York State. *N. Y. State Mus.*, bull. 112, economic geol. 16, 80 pp.— PILSBRY, H. A. Hawaiian Cirripedia. *Bull. U. S. Bur. Fisheries*, vol. 26, pp. 179–204, pls. 4–11.— TENNEY, A. A. Social democracy and population. *Studies in History, Economics and Public Law*, vol. 26, no. 4, 89 pp.

LELAND STANFORD JUNIOR UNIVERSITY, REGISTER FOR 1906-1907.— NINETEENTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.— NINETEENTH ANNUAL REPORT OF THE RHODE ISLAND EXPERIMENT STATION.— TRANSACTIONS OF THE AMERICAN MICROSCOPICAL SOCIETY, vol. 27.— UNIVERSITY OF COLORADO STUDIES, vol. 4, no. 4.— UNIVERSITY OF MONTANA REGISTER, 1906–7.

(No. 488 was issued August 26, 1907.)

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS
WILLIAM E. CASTLE
EDWIN G. CONKLIN
CHARLES B. DAVENPORT
HERBERT S. JENNINGS
FRANK R. LILLIE
JACQUES LOEB
THOMAS H. MORGAN
GEORGE H. PARKER
CHARLES O. WHITMAN
EDMUND B. WILSON

ROSS G. HARRISON, Managing Editor

CONTENTS OF VOLUME IV

NO. 1, FEBRUARY, 1907

Abnormal Development of Toad Ova Fertilized by Spermatozoa Exposed to the Roentgen Rays . . . . Charles R. Bardeen
An Ecological and Experimental Study of Sarcophagdae with Relation to Lake Debris . . . . . William B. Herms
Rejuvenescence as the Result of Conjugation . . . . Sara White Cull
Artificial Parthenogenesis in Thalmessema Mellita . . . George Lefevre
Concerning the Theory of Tropisms . . . . . Jacques Loeb
The Mechanism of the Galvanotropic Orientation in Volvox Frank W. Bancroft

NO. 2, MAY, 1907

The Influence of External Factors, Chemical and Physical, on the Development of Fundulus Heteroclitus . . . Charles R. Stockard
The Energy of Segmentation . . . . . Edward G. Spaulding
Movement and Problem Solving in Ophuria Brevispina . . Otto C. Glaser
The Occurrence of a Sport in Lina Lapponica and its Behavior in Heredity . . . . . Isabel McCracken
Experiments in Transplanting Limbs and Their Bearing upon the Problems of the Development of Nerves . . . . Ross G. Harrison
Factors in the Regeneration of a Compound Hydroid, Eudendrium ramosum . . . . . A. J. Goldfarb

PRICE OF SUBSCRIPTION PER VOLUME

(PAYABLE IN ADVANCE)

To subscribers in the United States, Canada and Mexico	$5.00
To subscribers in other countries	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to the Journal of Experimental Zoology

ADDRESS ALL COMMUNICATIONS TO

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

N. E. Cor. Wolfe and Monument Streets

BALTIMORE, MD., U. S. A.

The first of a series of Colored Plates of the

THRUSHES
OF
NORTH AMERICA

By FUERTES & HORSFALL,

was published in BIRD-LORE for February.

The series will be concluded this year

20 CENTS A COPY. $1.00 A YEAR

THE MACMILLAN CO.
NEW YORK CITY

THE AMERICAN JOURNAL OF SCIENCE

Established by BENJAMIN SILLIMAN in 1818

The Leading Scientific Journal in the United States

Devoted to the Physical and Natural Sciences, with special reference to Physics and Chemistry on the one hand, and to Geology and Mineralogy on the other.

Editor: EDWARD S. DANA

Associate Editors: PROFESSOR GEORGE L. GOODALE, JOHN TROWBRIDGE, W. G. FARLOW, and WM. M. DAVIS, of Cambridge; PROFESSORS A. E. VERRILL, HENRY S. WILLIAMS, and L. V. PIRSSON, of New Haven; PROFESSOR G. F. BARKER, of Philadelphia; PROFESSOR JOSEPH S. AMES, of Baltimore; MR. J. S. DILLER, of Washington.

Two volumes annually, in **monthly numbers** of about 80 pages.

This Journal ended its *first* series of 50 volumes as a quarterly in 1845; its *second* series of 50 volumes as a two-monthly in 1870; its *third* series as a monthly ended December, 1895. A FOURTH SERIES commenced in January, 1896.

Subscription price $6.00 per year or 50 cents a number, postage prepaid in the United States; $6.40 to foreign subscribers of countries in the Postal Union. A few sets on sale of the *first*, *second*, and *third* series at reduced prices. *Ten-volume index numbers* on hand for the second and third series.

THE AMERICAN JOURNAL OF SCIENCE

NEW HAVEN, CONN.

FOR BIRD STUDENTS AND BIRD LOVERS EVERYWHERE.

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

EDITED BY J. GRINNELL.

OFFERS IN VOLUME 9

In MAKE-UP, the highest grade in paper, typography and illustration and every detail that counts.

In ILLUSTRATION, the best work of Messrs. Finley and Bohlman, work that is unsurpassed in any field.

In SUBJECT MATTER, the results of recent studies by active workers in the western field; interest and scientific value, the standard.

SUBSCRIPTION, $1.50 PER YEAR. SAMPLE COPY, 30 CENTS

H. T. CLIFTON, BUSINESS MANAGER, P. O. BOX 404, PASADENA, CAL.

ALONE IN ITS FIELD

THE LIVING AGE

is the only American Magazine exclusively devoted to the reprinting, without abridgment, of the most important and interesting articles from the best English periodicals.

Published weekly, it is able to present this material while the topics considered are still fresh in the public mind.

With the whole range of English periodical literature to select from, it is able to present more important articles by well-known and brilliant writers than any other single magazine. It publishes

The Best Fiction **The Best Essays**

The Best Literary Criticism

The Best Travel Articles

The Ablest Discussions of Public Affairs

The single numbers are light and easy to hold, and the reading matter is not smothered in advertising. The numbers for a year contain as much as two of the four-dollar magazines.

The LIVING AGE has been published every Saturday without missing an issue for more than 63 years, and was never more indispensable than now to intelligent readers.

New subscribers for 1908 will receive free the remaining numbers of 1907 from the date on which their subscriptions reach the publishers. Specimen copy free.

Terms: $6.00 a year

Three Months' Trial Subscription, $1.00

THE LIVING AGE COMPANY

6 Beacon Street, Boston, Mass.

VOL. XLI, NO. 490 OCTOBER, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

Page

I. Studies of Gastropoda. III On Orthogenetic Variation in Gastropoda
AMADEUS W. GRABAU 607

II. Mutations and the Geographic Distribution of Nearly Related Species in Plants and Animals . . . . . J. A. ALLEN 653

III. Notes and Literature: Scientific Exhibits at the Seventh International Zoological Congress.— *Zoology;* The families and genera of bats.— Birds of North and Middle America.— *Botany;* Floral ecology . . . 657

IV. Publications Received 676

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York.*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALES HRDLICKA, M.D., *U. S. National Museum, Washington.*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley.*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History, New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology, Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts, books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *October, 1907* No. 490

STUDIES OF GASTROPODA

III. ON ORTHOGENETIC VARIATION IN GASTROPODA[1]

AMADEUS W. GRABAU[2]

ORTHOGENETIC variation may be defined as progressive variation along definite or determinate lines, whether such variation is along the line of increasing or decreasing complexity; i. e., aggradational or degradational. In the first place orthogenetic variation is *ontogenetic*; i. e., the successive changes which the individual undergoes in its transformation from embryo to adult follow each other in definite succession, the changes appearing step by step. When we are convinced that the changes seen in the development of the individual are reminiscent of the changes passed through by its successive ancestors, it becomes apparent that *phylogenetic* variation is also orthogenetic, or along definitely determinable lines.

It has been the general custom to test the validity of the recapitulation theory by the embryological method; i. e., the comparableness of the changes which the individual undergoes during its embryonic period, to the adults of more primitive types. Usually the comparison has been with adults of existing types, since in most cases these alone were available for comparison. It is no wonder, then, that such comparisons have led to innumerable errors, if not absurdities, which have placed the recapitulation

[1] The previous numbers of these "studies" appeared in the *American Naturalist* as follows: No. I, vol. XXXVI, no. 432, pp. 917–945, Dec. 1902; No. II, Fulgur and Sycotypus, vol. XXXVII, no. 440, pp. 515–539, Aug. 1903.

[2] Investigations carried on by the aid of a grant from the Hermann Fund of the council of the Scientific Alliance of the city of New York.

theory in an evil light, and awakened in the minds of many serious investigators doubts as to the validity of the deductions based upon this doctrine. When, however, the entire life history of the individual is considered, instead of only the embryonic period, and when the successive stages of epembryonic development are compared with the adult characters of related types in immediately preceding geologic periods, it will be found that the fundamental principle of recapitulation is sound, and that the individuals do repeat in their own epembryonic development the characters of their immediate ancestors.

One of the great mistakes made by the majority of systematists is the disregard of the immature stages of development; i. e., the stages between the embryonic and adult. This is notably the case among writers on recent mollusks, who either ignore the early stages entirely in their specific description or give them the briefest notice. And yet it is in these early stages that we find the key to the affinities of a given species with others of its kind, in the present and in past faunas, more often and more surely than in the adult characters. To classify by adult characters only is to neglect the nearest and most obvious method for the ascertainment of the line of descent of the species in question; and, further, it is to leave out of consideration the inevitable similarity produced in the aspect of adult types of different origins, by a loss of the characters distinctive of their respective ancestors and of their younger stages. The classification into one family of all bald headed men of the same age would not be more illogical than some of the classifications of phylogerontic mollusks in vogue today,— classifications based wholly on adult characters. Agassiz long ago called attention to the need of considering the stages between the embryo and adult, as the following extracts will show.

"Embryologists have generally considered their work as completed when they have traced the new being to a point at which it resembles somewhat any of the members of the natural group to which it belongs. The process by which the gradual completion of the whole frame is attained has been assumed to be of little interest, hardly deserving the careful scrutiny of the embryologist; while the zoologist has also overlooked, or regarded as of little importance, the differences which still distinguish the young from

the adult, even after its typical characters are perfectly distinct."[1] And again: "....I would say to all young students of Embryology that their next aim should be to study those intermediate phases in the life of a young animal, when, having already acquired independent existence, it has not yet reached the condition of the adult. Here lies an inexhaustible mine of valuable information unappreciated, from which....may be gathered the evidence for the solution of the most perplexing problems of our science."[2]

Availability of the Mollusca for the Study of Developmental Stages

Of all classes of organisms, the mollusks are perhaps the best adapted for the study of ontogenetic stages between the embryo and the adult, since all these stages are preserved as a permanent record in the form of the shell. Such a record cannot, of course, be obtained from the soft parts, where a number of individuals are necessary to represent the principal stages. Moreover, a certain step in development may be very definitely indicated in the form and sculpture of the shell, and yet be entirely unrecognizable in the soft parts. Not only, then, is the shell a permanent record of the changes, but it is also a more delicate register of advancement than is afforded by the soft parts. In other groups of organisms, the record is seldom so compiete, though brachiopods and corals retain, in perfect specimens, all the earlier stages. Other organisms, however, such as the echinoderms and vertebrates, preserve in their hard parts only the record of the stage at which the animals die, since these hard parts undergo individually constant changes from youth to maturity.

Among the mollusks, the gastropods and cephalopods are the most satisfactory for ontogenetic investigations, since in them the early stages are not only well preserved, but there are also a large number of characters the progressive variations of which may be studied. In many respects gastropod shells are the simpler to study, because the greater parts of the whorls are freely exposed

[1] Agassiz, Methods of Study in Natural History, Chapter XVI.
[2] Ibid., Chapter XV.

and open to observation, whereas in the coiled cephalopod shells the outer whorls must be removed before a satisfactory view of the inner ones can be obtained. Despite this fact, the study of shell ontogeny has been mostly confined to the cephalopods, especially to the highly complex and often richly ornamented ammonite shells; and this can hardly be wondered at, when we consider their number, and the high degree of diversity found in this group of organisms.

ORTHOGENESIS IN THE ONTOGENETIC DEVELOPMENT OF GASTROPODS

The individual development of gastropod shells always follows one of a small number of lines of variation. Leaving aside color markings, which have been somewhat fully discussed by the Countess von Linden,[1] we may devote this discussion to the changes in form and ornamentation. At the outset, however, we must note that in every perfect shell there are two parts to consider; namely, the protoconch and the conch. These may be continuous with each other, in which case the features of the protoconch merge into those of the conch; or they may be discontinuous, when the protoconch features end abruptly and the conch features begin as abruptly. (See Studies of Gastropoda, I, fig 5.)

The form of the gastropod shell is manifold, but the types are few. Primitive types always begin with rounded whorls free from all ornamentation. The coiling of the whorls at first is in a sufficiently loose manner to produce a hollow axis, opening below in an umbilicus. Even in types in which the anterior end of the adult is produced into a canal — as in Fulgur, Buccinum, Fasciolaria, etc.— the earliest protoconch stage has been found to show the umbilicated round-whorled condition (Studies of Gastropoda I, fig. 3). This condition may be accompanied by various modifications in the amount of embracing of the succeeding whorls. In all cases a moderate amount of embracing by the succeeding whorls seems to be the simplest condition, although it must be borne

[1] Die Entwickelung der Skulptur und der Zeichnung bei den Gehäuseschnecken des Meeres. *Zeitschr. f. wissensch. Zoologie*, LXI, p. 261.

in mind that a difference may here be found between protoconch and conch. When the whorls embrace but slightly, a deep suture is produced between them. In this case the spire also is a slender one, as is shown in so many primitive fusoid shells (Studies I, fig. 6). As the amount of embracing increases, the suture becomes less strongly depressed, and the spire takes on an ever greater apical angle. The amount of embracing may increase until the suture is found at the ambitus of the preceding whorl (Studies II, fig. 13). Beyond this, the embracing is only carried in the old age of the individual of normal types or in specialized types, generally the members of a phylogerontic series.[1]

In a large number of types, the amount of embracing by the whorl remains practically the same throughout life, thus giving the spire a uniform angle. In others, again, and perhaps in the majority of specialized types, the embracing is at first less, but slowly increases in amount with each succeeding whorl in the later stages (Fig. 1).

Even in degradational types, where the embracing of the adult shell is in extreme excess of that of the normal adult type, the amount of embracing increases regularly from its first appearance to the completion of the growth.

There is another extreme found in phylogerontic members of a certain group of Gastropoda and so far observed in the non-canaliculate types only; namely, the loss of the power to coil, due to the equalization of the rate of increase in all portions of the shell (Studies I, figs. 14 and 15). This results in a looser coiling or complete straightness of the final portion of the last whorl, and may or may not be accomplished by an increase in the diameter of the whorl. Ontogenetically this is often expressed by a progressive loosening of the coil, though there are various degrees of abruptness, some coils becoming gradually straightened, while in other types this straightening appears very abruptly. As will be shown presently, the loss of power to coil and the excessive spread-

[1] The nomenclature of stages in development, devised by Hyatt, Buchmann, Bather and others, is for ontogenetic stages as follows: *nepionic*, babyhood; *neanic*, youthful or adolescent; *ephebic*, adult; *gerontic*, old age or senile. Corresponding stages in phylogenesis are designated by the prefix *phylo*, but the term *phylogerontic*, or racial old age, is the only one in common use.

ing of the whorl are generally accompanied by the loss, or at least a modification, of the ornamentation.

A second important type of modification of form in ontogeny is the angulation of the whorls. This begins as a slight depression in the curvature of the upper or shoulder portion of the whorl, and a similar depression of the lower or body portion. Thus a faint angulation appears in the ambital portion of the whorl, which usually occurs where the whorl is marked by the first or most pronounced of the spirals. From a faint beginning, the angle increases in sharpness, and the depression of the shoulder surface and body surface increases, until the whorl consists of two perfectly flat or even slightly concave surfaces separated by a sharp angle (Fig. 2). Where the angulation appears late in the ontogeny, generally about an equal flat space is shown above and below the angle (Fig. 8). When it appears early, the later whorls generally embrace the preceding more strongly, thus decreasing the space below the angle, until in extreme cases this lower space has entirely disappeared, the suture of the succeeding whorl being at the angle (compare Fig. 5 with the younger portion of another individual enlarged in Fig. 2). This produces a continuous slope of the spire, which may vary, in different types, from nearly horizontal as in Conus, where the shoulder makes a right angle with the axis of coiling of the shell, to nearly vertical as in some Turritellas and Cerithium, where the shoulder makes a very acute angle with the axis of coiling, and the ambital angulation is far down on the shell. In all such cases, however, it is the rule that the earlier whorls are less closely coiled, so that in the young spire the flattened body of the whorl, below the angulation, becomes visible (Fig. 2). This is true even of such highly specialized types as Conus, where the shoulders alone of all the later whorls are visible; for the young whorls here project commonly above the general surface, showing a more steeply sloping shoulder, and generally exhibiting a portion of the whorl below the angulation, though this portion may be the merest fraction of the whorl. Rarely has acceleration gone so far that the shell begins with an angle and the whorls embrace up to the angle. The norm of the embracing, as in the slope of the shoulder, seems to be that which approaches most nearly to the round-whorled condition; i. e., an equal exhibition of flattened

shoulder and body, and approximately an angle of 45° between the shoulder and the axis of coiling. From this the progressive change is to a steeper shoulder in one series and to a flatter shoulder in the other. Similarly, the partial embrace of the whorls seems to be the norm, from which variation on one hand is in the direction of more pronounced embracing, carried to excess in phylogerontic

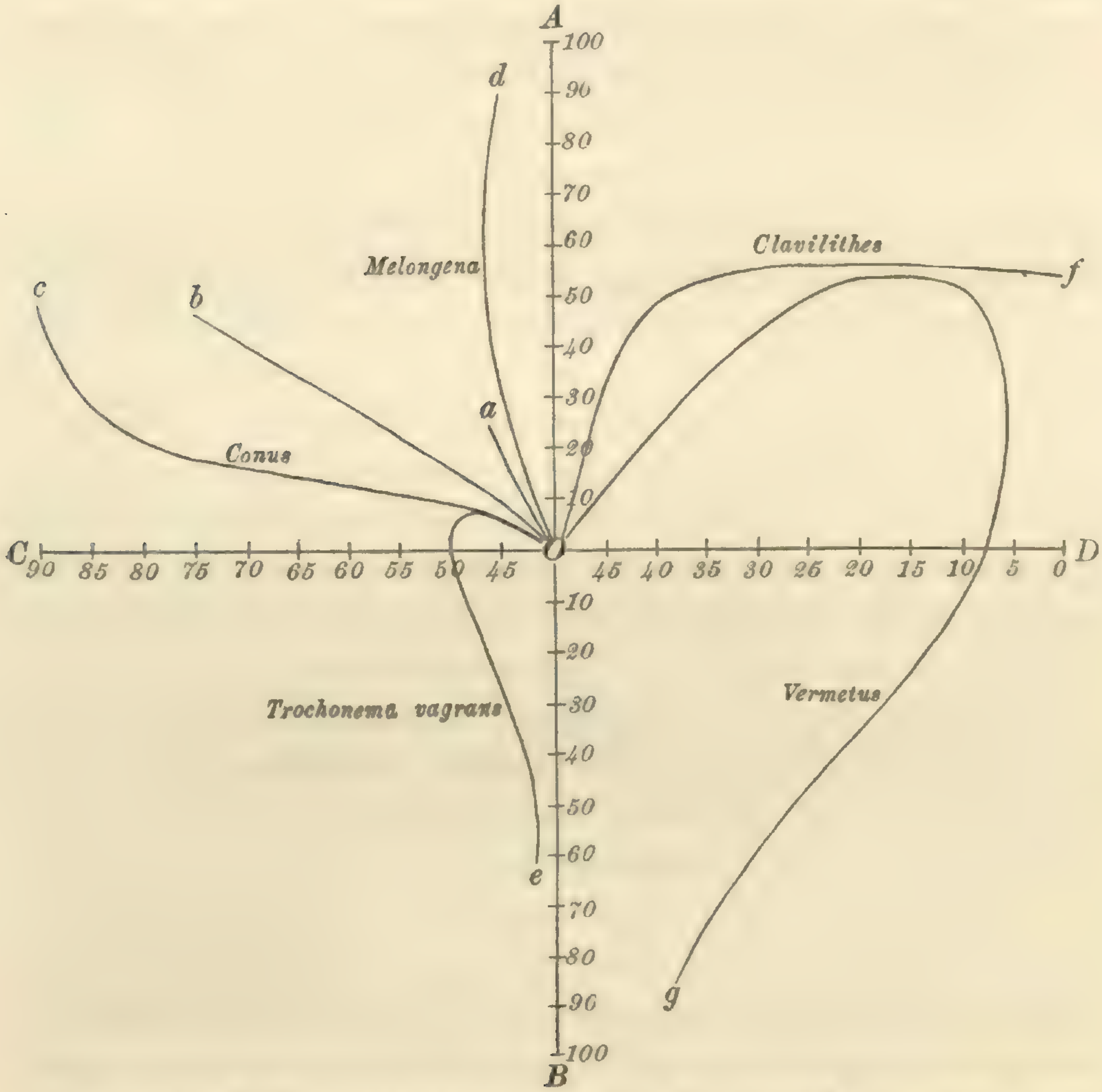


Diagram 1.—To illustrate the development of various types of gastropod shells, as explained in the text.

types, and in the other to a gradual loss of power to coil, which also terminates in a phylogerontic condition. These relationships may be represented in the following manner (Diagram 1).

The ambitus of the whorl, or the point of greatest convexity, is taken as the center of the whorl. The line $O - A$ represents progressive increase in embracing, from zero at O to 50% at the ambitus, and to complete overlapping and concealing of the pre-

ceding whorl at A (100%). $O - B$ represents progressive loss of coiling power to straight conditions at B; $O - C$, increasing horizontality of shoulder from round at O to 45° and thence to horizontal or 90° with reference to the axis of coiling. $O - D$ in the same way represents increasing verticality from 45° to 0°, or parallelism with reference to the axis of coiling, at D.

A simple round whorled shell in which the whorls do not embrace throughout life (primitive Fusus) would be represented by the point O. One in which a slight amount of embracing occurs, but no change in outline of whorl, is represented by a line on $O - A$, the length of which marks the percentage of embracing up to 50 at the ambitus or more if the whorls overlap. The line may not start at O but higher up, the earlier whorls showing some embracing. The line $O - a$ represents the life of a shell in which the whorls gradually change to angular (45°) and the embracing increases up to 25% or half way to the ambitus.

$O - b$ represents a shell with gradual increase of embracing of whorls to ambitus, and flattening to 75° with reference to the axis of coiling, as in some Fulgurs. $O - c$ represents a more rapid flattening than increase in embracing, as in Conus; $O - d$ a gradual increase in embracing to below the ambitus, while at the same time the whorls are flattened to a shoulder of 45°. Then the embracing continues to the ambitus, beyond which, with increasing embracing, the whorls lose their angularity. This is seen in Melongena. In Clavilithes, represented by $O - f$, embracing increases to the ambitus, after which the whorls become quickly flattened vertically to 0°. Vermetus is represented by $O - g$, in which increasing embracing and flattening to 10° or less represents the Turritella stage, after which a loss of the embracing finally brings us to the loose coiling type with a return to round whorled condition. Similar changes are seen in *Trohonema vagrans* (Studies I, fig. 15) where angular embracing whorls are succeeded by loose rounded ones.

ORNAMENTATION OF THE WHORLS.

As already shown in the first of these studies (*Am. Nat.*, XXXVI, p. 930) the ornamentation of the whorl consists of ribs, spirals,

tubercular keel, and spines. Of these, so far as ascertained, the ribs generally appear first, though in a group of early gastropods in which ribs are never developed in the adult, spirals may be well developed. The point of importance, however, is not the relative time of appearance, but the mode of development of each, and their influence upon each other when they occur together. Where the development is complete, the ribs are at first faint vertical ridges upon a rounded whorl, enlarging gradually until they are strong, rounded, elevated ridges extending from suture to suture, with their greatest prominence at the ambitus of the whorl (Figs. 16–17). From being at first rather distant, they may increase in breadth until they are separated only by a depressed line. With the appearance of the ambital angulation, the ribs become fainter towards the sutures, while at the same time they become more pronounced upon the ambitus. Eventually the ribs disappear entirely from the shoulders, disappearing at the same time or somewhat later from the body of the whorl below the shoulder angle. Then only a regular row of tubercles remains behind, each tubercle being the concentrated essence of the ribs of the earlier stages (Studies II, fig. 10). Throughout, this process of metamorphosis is a regular progression, though in some (i. e., accelerated) shells it occupies a smaller number of whorls than in others. Up to this point there is uniformity in development of all ribbed shells with angular whorls following upon rounded ones. Beyond this point there is a divergence; along one line the tubercles gradually broaden and become confluent into a keel (Studies II, fig. 12) which forms a prominent and persistent character, disappearing only in old age types when the shell becomes rounded; along another line the keel, if it comes into existence quickly disappears, when the shell becomes rounded in outline. Upon this a new type of ornamentation, the spine, appears. This will be more fully discussed below.

The spirals.— These are continuous and persistent folds in the shell substance, caused by a slight emargination in the lip of the shell. This emargination corresponds to a faint wrinkle in the mantle when withdrawn, the growth of that organ being a more rapid one than is commensurate with the increase in diameter of the whorl. Thus while when expanded, the mantle is smooth,

when withdrawn it must be folded into minute wrinkles to become accommodated to the smaller space. That these spirals are generally visible only as emarginations on the margin of the lip, indicates that only the outer portion of the mantle is affected by this excess of growth. If other parts of the mantle are affected, lirae result on the inside of the outer lip and plications on the columellar lip.

The order of appearance of the spirals is a very regular and progressive one. In simple or primitive shells a single spiral makes its appearance at the ambitus, followed in most cases successively by spirals above and below. A partial exception to this rule is found in types in which a certain number of stages have been dropped out between the protoconch and conch and hence the conch does not begin at the beginning (Studies I, fig. 5) but at a stage normally belonging later in the ontogeny. Thus in Fusus, Latirus, Semifusus and certain Murices the conch begins abruptly with rounded ribs and three or more spirals. Such dropping out of early stages is however entirely in conformity with the general progress of development and is itself progressive, or orthogenetic. It belongs however in the category of phyletic orthogenesis.

At whatever stage of development the shell begins, that development is thereafter progressive. Thus in a large number of forms, if the shell begins with three spirals, the fourth, fifth and later spirals appear progressively above the upper, and below the lower one. If the whorls become asymmetrical, with continued growth, as is the case in the majority of shells where the lower (anterior) portion is either drawn out into a spindle and canal, or is flattened and depressed, the development of the spirals will be unequally distributed. Thus in shells with a spindle, three or four spirals may appear successively below, while only one appears above the ambitus.

In some cases as in Goniobasis, certain Melanias etc., the third and later spirals appear as intercalations between the first two. In this respect they resemble the secondary spirals to which indeed they may be closely allied. They however quickly reach the size and other characters of the two first spirals with which they appear to form the primary series (Figs. 13 and 18). Additional intercalated spirals with the habitat of the secondary spirals appear between them at a later period.

The manner of appearance of the spirals must be regarded as a consequence of the rate of growth of the mantle. Considering that the first two spirals are the result of the first two folds into which the mantle border is thrown on retraction, and assuming that the position of these folds is a permanent one as appears indeed to be unquestionable from the continuity and regularity of the spirals, we perceive that if the mantle border grows more rapidly above and below the original folds than between them, the new spirals will appear respectively above and below the first two. If on the other hand the mantle grows fastest between the two original folds, the corresponding spirals will diverge and new ones appear between them. This is the case in the formation of the secondary spirals in the Fusidae and other forms. The question may well be asked if these two modes of appearance of the early spirals do not represent two lines of development originating independently in various genetic series and producing end-members, which, within the same series, are indistinguishable in their adult characters. If, on the other hand, we regard intercalation as the method of appearance of secondary and later spirals, then Goniobasis and the Melanias and other types which show intercalation after the appearance of the first two spirals, must be considered as highly specialized and accelerated types.

When the full number of primary spirals has appeared, or in accelerated shells at an earlier period, intercalated spirals appear, beginning in the broadest interspaces. In fusoid shells this intercalation begins on the spindle, where expansion is most pronounced. Secondary spirals are followed by tertiary ones, and sometimes by spirals of a higher order, all being intercalations between the primary ones. The first spiral generally marks the point at which the ambital angulation occurs. A strengthening of this spiral is, indeed, often the first indication of approaching angularity, and in some cases the change of whorl does not progress beyond this point. When the central spiral continues to increase in size, after the ribs have been reduced to nodules, the form of these nodules will be influenced by the spiral, so that instead of knobs they will be elongated, rounded, and flattened nodes. Such a condition is well shown in *Fusus distans*. This condition often ends in complete confluence and the formation of a keel (*Sycotypus canaliculatus*).

Spines.— These are of two kinds in gastropods. In a number of phylogerontic platyceroids they consist of tubular prolongations from the surface of the shell at irregular intervals, and appear to be of little phyletic significance. The other, more important type represents a periodic emargination in the lip of the shell (Figs. 3–4, 7–8). That the periodicity of this spine formation is connected with the regular recurrence of the reproductive period, may be assumed for types in which these spines appear late in the ontogeny; but not for those in which they appear early. Direct observations in this field seem to be wanting, however. The rate of growth of the shell during the interval between such periods of spine formation determines the number of spines upon a volution. As has been shown for Fulgur (Studies II, p. 534) the number of periods in progressive types decreases as the shell increases in size, thus showing that the amount of growth between resting stages (i. e., spine forming stages) increases at a rate faster than the rate of increase in the size of the shell. This may of course also be interpreted as a lengthening of the time interval between resting stages, or possibly between the reproductive periods. In some forms the decrease in the number of spine periods to the whorl is a rapid one, as in *Fulgur eliceans*, where it is 12, 9, and 6 respectively for the 5th, 6th, and 7th whorl, whereas the decrease is 14, 13, 12, or 13, 12, 11 for the same whorls in *F. carica*. In *Murex* (*Rhinocanthus*) *brandaris*, on the other hand, it is 6, 6, and 7 for the 5th, 6th and 7th whorl respectively, thus showing a shortening of the growth periods. In the majority of Murices, however, the number of periods has been reduced to three for all whorls. In Ranella the number of resting stages as expressed by the varices has been reduced to two for each whorl.

The simplest spine is that found in Fulgur. It has been quite fully described in a preceding number of these "Studies" (II) and the only point that needs to be emphasized in this connection is the gradual appearance of the spine in the ontogeny of the individual. This is not noticeable in *Fulgur carica* or other accelerated types of Fulgur, as fully discussed in the papers referred to, but is well shown in the more primitive Miocene types (e. g., *F. tritonis*, fig. 7). Here the spines appear on a faintly keeled or smooth shell, and at first are in the form of the merest faint spinelet, scarcely

noticeable, though recognizable to the touch as a faint protuberance. From this beginning the spine grows, period by period, until it has become of the normal adult dimensions. In some forms the spine continues to grow throughout life, giving us the enormous spines of *Fulgur candelabrum*.

Where a second row of spines appears this always comes in later than the first, though acceleration may tend to shorten up the interval, or even by dropping out the earliest stages produce a type in which more than one spine appears at the beginning of the conch stage. Tudicula is a good example of normal succession in the appearance of spine rows. In the Miocene *T. rusticula*, only a single row of fulguroid spines appears on the ambital angulation (Fig. 3). In *T. bispinosa* sp. nov.[1] (Figs. 1, 3 and 4) the spines of the first row increase in size, progressively though slowly while a second row of spines makes its appearance lower down on the body whorl, after the first has been in existence for a considerable number of volutions. This second row begins with the merest elevation, scarcely visible though noticeable to the touch (Figs. 1 and 3). From this beginning the size of the spine increases period by period, until the spines of the second row are equal in size to those of the first (Fig. 4). In accelerated types, the second row is already well developed in the young individuals (Fig. 1).[2] In the modern *Tudicula spirillus*, a beginning of the second row of spines is indicated by a succession of faint elevations, each later one stronger than the preceding, but none reaching the dignity of true spines. When more than two spines occur, these follow the same rule, as may be seen in *Murex brandaris*, *M. tenuispina*, etc.

In all cases the spines appear on the spirals, representing periodic outgrowths of the emargination which originally formed the spiral. As already noted, the first spine occurs on the spiral occupying

[1] I have been unable to find that a specific or varietal name has been proposed for the forms with a double row of spines, and hence propose to use the above name for them. I am well aware that intermediate forms between those with single spinous keel and those with double spinous keel exist, but I do not consider that this militates against the specific standing of the two types.

[2] For a full illustration of the principal mutations of the Miocene Tudiculas, see Hörnes und Partsch,—Die fossilen Mollusken des Tertiär-Beckens von Wien. *Abh. d. k. k. geol. Reichsanstalt*,1856, Bd. 3, Taf. 27.

the summit of the ambital angulation. The second row of spines generally forms on the spiral which separates the body of the whorl from the spindle. The larger spines are formed on the primary spirals, the smaller intermediate ones on the intercalated secondary and tertiary spirals. In a number of types these spines are independent (*Murex tenuispina*) while in others they become compounded. Thus in the majority of Murices, the spines of the later cycles do not become independent of those of the earlier cycles, since these earlier ones grow to such an extent that the independence of the smaller spines is impossible. Hence they become modifications upon the sides of the larger spines, and thus is produced the wonderful complexity of spine in such forms as *Murex palmarosae* and others. Here, too, as has already been shown (I, p. 934) the increase in complexity is progressive from period to period, the first formed spine on the ambitus (or shoulder angle) always leading the others. The degree of advance of the first over the second spine varies in amount in differently accelerated types; this variation is, however, phyletic and as such also progressive. In some types the second spine always has the complexity of the first spine in the preceding period, in others its complexity is comparable only with that of the primary spine in a still earlier period.

Columellar plications and lirae.—The development of these features also follows the law of progressive appearance and progressive intensification. Those types like Fasciolaria, Rhopalithes, Latirus, etc., which in the adult have several plications, are as a rule, free from these in the earliest stages. The only exception is in the case of accelerated types, which start conch-life already equipped with plications, as many of them start equipped with costae and spirals. In the more primitive types, however, the plications appear in succession, the first while the shell is still young, the others successively. In some cases the second plication has only reached half the size of the first in the adult shell. In types with numerous columellar plications, intercalated ones appear between the older ones. These begin chiefly in later stages of development, being absent or at least weak in the younger stages. This is well seen in the young of certain volutes, such as *Voluta musica* and *V. polyzonalis*, where the intercalated plications in

half grown shells are absent or much more weakly developed, than in the adult.

In the same way lirae appear later in the life of individuals, being absent from the earlier stages. They are furthermore often complicated by intercalations, which like the primary ones appear progressively.

Summary of Appearance of Shell Characters.

Summarizing the results so far obtained, we note that all the characters of the shell appear in a definite order, and develop by a process of progressive intensification or growth. This law holds good in the most diverse types of gastropods as will be more fully apparent from the examples cited below as illustrations. Even where at first glance the order of development seems to be abnormal, it is seen on closer inspection that this apparent abnormality is due either to normal progressive acceleration—falling as such under the type of variation outlined in the next section, or to pathologic conditions, which cause a temporary, or sometimes permanent development of senile characters which in the normal course of the ontogeny would appear only towards the end of life.

Phyletic acceleration, or the condensation and elimination of stages normal to the ontogeny is one of the chief sources of anomalies in the ontogeny. When the elimination is at the beginning of the conch stage, the shell may be looked upon in the same light as a more primitive type in which the apical portion has been broken away. In both cases the available part begins some stages along the road of progress but in both cases the stages subsequently passed are the same, though one may go at express rate and the other at a slow pace. When however later stages are telescoped, as is the case in many accelerated forms (*Fulgur carica*, *F. elicans*, *Fusus longicaudus*, several species of Semifusus, Pugilina, etc.) the recognition of the normal line of progress is not so easy. Nevertheless it becomes apparent that up to the point of telescoping, and from that point onward, the progress is a normal one. Merely an original detour has been cut off as a river in the course of its development cuts off a large meander, and so two points, originally far apart on the river's course are brought close together.

Many other characters of the shell, such as the outline of the spindle, and the formation of anterior and posterior canals, and the development of the color pattern, have not been touched upon, but they all proceed according to a uniform law of change. The Countess von Linden has endeavored to show that the transformation of the color pattern in marine gastropods follows Eimer's law, viz: longitudinal striping, spots, cross-stripings and uniform color.

ORTHOGENESIS IN PHYLETIC DEVELOPMENT OF GASTROPODA.

The protoconch, the last of the embryonic stages, is far less satisfactory for purposes of tracing phyletic relationship, than is the conch. Nevertheless, up to a certain point, it may, I believe, be confidently relied upon. That an early stage of the protoconch in the majority of gastropods is of the form of a simple naticoid coil with a well-marked umbilicus, has already been noted (Studies I). As stated in the first of these studies this form of the protoconch recalls the character of the earliest known coiled gastropod, i. e., *Stroparollina remota* of the lower Cambric of the Atlantic coast province. Still earlier stages in the development of the protoconch show a capuloid form, which recalls the adult character of many of the early Cambric shells described under various names. That all of these are not primitive but that some are phylogerontic, is shown by the fact that the earliest stages are enrolled while the later stages are non-coiling. Sardeson[1] has indeed insisted that my interpretation of such forms as *Platyceras primaevum* etc. as phylogerontic is erroneous, and he has attempted to show that the forms with slightly coiled apex are more advanced than those in which the apex is not coiled at all, and that the progress of development is from forms without any coiling through those with enrolled apex, to the close coiled types. That this is a complete inversion of the mode of coiling, must be apparent when we consider that the animal has no more power to enroll its apex, than it has to unroll it, and that, since the apical part is the first-built

[1] The Phylogenic Stage of the Cambrian Gastropoda. *Journal of Geology*, Vol. XI, p. 470–482.

portion of the shell, it represents the primitive condition and the straightened part represents the later condition. Thus the progress of ontogenetic development is from close-coiled to non-coiled, from which we are justified in deducing that the ancestor of the type with the enrolled apex was a closely coiled type, and that the loss of power to coil, shown in the adult, is a sign of old age of the branch which that individual represents. That the earliest types were non-coiling shells cannot be doubted: there is every reason for believing that they were patelloid in form, though modern Patella is a phylogerontic type, which in its adult characters has returned to the condition of its forefathers. This is clearly shown by the presence of the coiled protoconch which at once stamps this form as derived from a coiled ancestor. All deductions then based on the anatomy of the soft parts of Patella, which leave this fact out of consideration are necessarily faulty, since it is hardly conceivable that in all its characters this animal has either remained primitive, while the shell passed through a tremendous series of metamorphoses, or that the soft parts have likewise degenerated to such an extent that they have reached in all characters the condition of the primitive ancestor of the gastropods.

Another relationship that may be deduced from the structure of the protoconch of many highly ornamented types of shells, is that they were derived from an ancestor with simple ribs on rounded whorls. Thus the ancestors of Fusus, certain Murices, Latirus, Tudicula and other types were fusoid shells with simple ribs on smooth rounded whorls, if the structure of the protoconch of these types can be regarded as an indication of ancestral conditions. For in these types the last portion of the protoconch is ribbed with delicate vertical ribs but without spirals. While the community of descent of the genera cited from some early Mesozoic ancestor is probable, it does not follow that all ribbed protoconchs indicate a common ancestry. For when it is recalled that ribs appear independently in the most divergent types of shells, it need not surprise us to find that this primitive ribbed character has been pushed back into the protoconch stage in a number of different lines of descent.

There are, of course, not wanting those who deny that the characters of the protoconch can be regarded as indicative of phyletic

relationships. Indeed the common practice of classifying largely or wholly by adult characters has almost of necessity led to a minimizing of the value of protoconchial characters when they are recognized at all. When differences of protoconch features were found in types classed together as related from adult characters it was explained as the result of the influence of different physical conditions acting upon the embryo. This heterostylism as it has been called by Boettger,[1] is explained by him as probably having one of two causes — either it is developed through a process of selection, to give the animal a lighter shell, to enable the animal occupying it to change its location more easily and quickly — or it has the object to prevent the creature from sinking into the soft ooze of the deep sea bottom, in which for lack of food or for other reasons it would perish. This of course refers only to the young shell, for the size of the initial protoconch whorl can have little significance in the adult.

Heterostylism, or a difference in the character of the protoconch in individuals living under different conditions, has been shown to exist in *Murex tribulus* L., where Sturany found that the deep sea form differs from the littoral form in an embryonic end or protoconch with more strongly swollen apical whorl, and with an extra volution. *Fusus bifrons* and *F. paucicostatus* are also distinguished at an early age by the relatively more swollen protoconch of the latter, which is at home in deeper water (490–876 meters).[2]

These two cases were used by Boettger[3] to illustrate his heterostylism and to establish the non-validity of my contention that the character of the protoconch of Fusus, of Clavilithes, Rhopalithes, etc., are not only distinctive, but due to diversity of descent.[4]

[1] Boettger, O. Ueber Heterostylie bei Schneckenschalen und ihre Erklärung. *Nachrichtsblatt der deutschen Malakozoologischen Gesellschaft*; 1905, Heft 1.

[2] Sturany. Expeditionen S. M. Schiff Pola in das Rote Meer. *Zoologische Ergebnisse*, XXIII. Gastropoden des Roten Meeres. *Denkschr. Math. Nat. Cl. K. Akad. d. Wiss. Wien.*, 1903, Bd. 74.

[3] loc. cit.

[4] Grabau, A. W. Phylogeny of Fusus and its Allies. *Smithsonian Miscellaneous Collections.* Vol. XLIV, no. 1417, 1904.

A similar position with reference to my work is taken by Cossmann[1] whose criticisms are more fully considered beyond.

Referring again to the Red Sea shells cited by Sturany, and used by Boettger and by Giard[2] as illustrations of heterostylism in Gastropods due to diverse physical conditions, we note on reference to Sturany's illustrations that the difference between the protoconchs of *F. bifrons*, and *F. paucicosta* is one of degree and not of kind. Both protoconchs are of the same type, the true Fusus type; but that of *F. paucicosta* has a somewhat larger initial whorl. This species is a highly accelerated type, as compared with *F. bifrons*, and hence it is not surprising to find the protoconch partaking of this acceleration. Besides the initial larger whorl, the number of whorls appears to be less than in *F. bifrons* where $1\frac{1}{2}$ smooth volutions, followed by a delicately ribbed portion constitute the protoconch. Reference to my figures and descriptions of protoconchs of Fusus will show many such variations, (see pl. xvii, figs. 1–4) all of which are mere modifications due to greater or less acceleration, *but do not constitute an essentially different type of protoconch.* Such a difference of type does however exist between the protoconchs of Fusus and Falsifusus and Fulgurofusus, and between Clavilithes and Rhopalithes as a critical study of these will no doubt convince anyone. Where in Fusus of the Red Sea, the deep sea form has a larger initial and fewer subsequent whorls in the protoconch than is found in the littoral species, the deep-sea form of *Murex tribulus* combines according to Sturany a large initial with more numerous subsequent whorls when compared with the littoral type. In the absence of figures and detailed description such as one has a right to expect in a work of the kind presented by Sturany, it is impossible to judge in what this difference really consists. Moreover, one is led to doubt the accuracy of Sturany's generalizations quoted with approval by Boettger, when the statement, "It appears from these tabulations that the deep-sea examples have a proportionally higher spire, due to the increase in the number of volutions," is compared with the table

[1] Revue Critique de Palaezoologie *Oct. 1904*, p. 233, and Essais de Paleoconchologie comparée, liv. 7, p. 225, 1906.

[2] Giard, Alfred. La Poecilogenie. *Bulletin Scientifique de la France et de la Belgique*, 1905, T. XXXIX, p. 160.

of measurements to which it refers. For here we find that the smallest number of whorls (6) is found in shells from the greatest depth (920 m.) while a littoral specimen has the largest number (9) except one which has ten volutions and was obtained from a depth of 740 meters. Judging by the actual number of whorls, there appears to be nearly a steady increase in the number from 920 meters to shallow water. Moreover, it does not appear from Sturany's table how he eliminates differences in age in the individual measured. Taking shells of the same number of volutions (8) and therefore presumably of the same age, we have for

920 meters in depth — a length of 73 mm.
920 " " " " " " $60\frac{1}{2}$ "
612 " " " " " " $41\frac{1}{2}$ "
212 " " " " " " 57 "

Subtracting the length of the spindle we have in the same specimens the following height of spire of 8 volutions.

920 meters in depth a length of spire of 35 mm.
920 " " " " " " " " 27 "
612 " " " " " " " " 22 "
212 " " " " " " " " $23\frac{1}{2}$ "

the greatest variation being within the same depth. Since the number of volutions is here the same, this difference in height can only be ascribed to a difference of embracing in the earlier whorls. A detailed description of this difference would have been of extreme interest, and as a record of variation would have been far more valuable than the tabulation of lengths and numbers of volutions, which without further discussion are of very little significance and value.

So long as the difference of protoconchial characters lies in the somewhat larger size of the initial whorl, or the relative number of whorls, this difference may very well be regarded as due to the difference of environment. That the environment may influence the development by retarding or accelerating it, seems hardly questionable, and that as the result of such retardation or acceleration the circumferential growth of the original shell may increase proportionately more rapidly than the spiral growth, thus producing a larger initial whorl, is also comprehensible. As is shown by studies of the embryonic development of *Fulgur carica* and

Sycotypus canaliculatus the size of the initial whorl is determined by the size of the embryo long before it leaves the egg-case, and in fact the whole protoconch is formed and the animal has begun the building of the conch before it becomes free. The same thing is true of *Fasciolaria gigantea* and *Buccinum undatum* (see Studies II, p. 535). To what extent this intracapsular development is carried on in the species of Fusus and Murex cited, I have not been able to ascertain, but it is most probably the case that the protoconch stage is far advanced if not completed before the animal becomes free. The size of the initial whorl of the protoconch is then probably to be regarded as an expression of the size of the embryo, its rapidity of growth during the period of formation of the hyaline primitive shell, and the size it has reached before the deposition of the calcareous matter begins. The size of the yolk of the eggs, i. e., the initial food supply may, in turn, be considered as at least a partial factor influencing this rate of growth. The factors advocated by Boettger are thus secondary factors which may or may not determine survival. They may indeed have no significance whatever, for swollen initial whorls are found in *Fusus colus* which lives in from 10 to 20 fathoms and *F. mamoratus* which lives in even shallower water. Among the Volutes, too, which are comparatively shallow water forms, species like *V. musica* have a minute apical whorl while *V. rupestris* Gmelin, probably belonging to a separate line of development, has a large initial whorl. The initial whorl of the shallow water Fulgurs, is much larger than that of many deep water species of other genera.

Aside from the size of the initial whorl of the protoconch, its obliquity to the axis of coiling of the other whorls is a significant feature. This is found in shells with an emargination or canal, that is fusoid shells, and can be traced back to the beginning of this canal. If the initial emargination, however, forms some distance from the umbilicus toward the periphery of the whorl, the later whorls will coil on a different plane from the first, which is often partially embraced by or becomes sunken into the second whorl (Fig. 6). This early rotation of the first whorl, occurring as it does in the capsular period of development, must be due to characters inherent in the embryo — at any rate it is difficult to conceive how it can be a product of environmental influence on the

animal after emergence from the capsule. It is of course possible that this rotation of the axis of the initial whorl may be a result of the rapid increase in size of this whorl since it nearly always accompanies such rapid increase, in which case it is a secondary feature.

I have elsewhere[1] described in detail the protoconchs of Rhopalithes and Clavilithes from the Calcaire grossier of the Paris Basin, and shown their great distinctiveness, the species classed under Rhopalithes having a fusoid protoconch with few riblets, while typical Clavilithes has a papillose one of numerous whorls, with other distinctive characters. I also showed that each genus embraced a series of species which in their stages of development paralleled each other and ranged from the round whorled, ribbed and fusiform type through a number of progressive changes, to an extreme old age or phylogerontic condition. I further pointed out that in spite of this remarkably close parallelism, the generic characters remained constant, the protoconchs of the two series remained distinct and Rhopalithes was throughout marked by the presence of columellar plaits (not always visible in old shells unless the lip has been broken back) which never occurred in Clavilithes. Moreover, the other shell characters are such that any one familiar with these shells can separate the members of the two series almost at a glance and without reference to the protoconch or columellar plaits. In spite of this Cossmann[2] insists, and Boettger follows him,—that my distinction is based solely on the difference in protoconchs; and that I carry my faith in the essential constancy of the characters of the protoconch and their phyletic value so far, that I have allowed myself to separate into two genera what M. Cossmann, and others who are accustomed to collect and study these shells in their type-localities, consider to be varieties of one species only. This arraignment might be more serious were M. Cossmann and other high authorities on the shells of the Paris Basin accustomed to study their species serially, and to give due attention to the early conch stages. M. Cossmann has recently taken to a recognition of the diverse characters of protoconchs, and in his valuable "Essais" has illustrated many of them. Unfortunately these illustrations are extremely crude,—often merely a spiral line—

[1] Phylogeny of Fusus, etc.
[2] Cossmann. *loc. cit.*

and the wonderful detail shown by many protoconchs is wholly unrecognizable. As for the characters of the early whorls, and their progressive changes, M. Cossmann, like most conchologists, either deems them of minor importance or of none at all, and does not grant them the space they deserve in his descriptions. No wonder then that he should be horrified at my audacity in making a new genus, where he sees only a variety. I was well aware that the species separated by me under the genus Clavellofusus were classed by French conchologists as varieties of *Clavilithes parisiensis* (which M. Cossmann still insists upon uniting with the British *C. solanderi* under the name *C. deformis* coined by Brander for the young of that or a related species) for I had specimens labelled thus, presumably by M. Cossmann's own hand; yet I found, and continue to find whenever a new specimen of this series comes under my observation, that the section denominated by me Clavellofusus with the rank of a genus, is wholly distinct from, and has its own series of mutations parallel to those of Clavilithes. Moreover, if Deshayes is to be believed, this series belongs to the *Sables inférieurs*, while Clavilithes belongs to the middle Calcaire Grossier (though one species has been recorded from the *Sables moyens*) except the most specialized terminal member of the group *C. scalaris* which is confined to the *Sables moyens* or lower Upper Eocene. All my material has shown, and I believe that a careful and unbiased study of other material will show that the Clavellofusus series is distinct from Clavilithes of the Calcaire Grossier, that it runs through its own series of modifications, some accelerated or tachygenetic, other retarded or bradygenetic, and that these various mutations[1] are derived from a Fusus-like ancestor, possibly a Fusus itself, and not from *Clavilithes parisiensis*, — a species appearing much later and belonging to a distinct genetic series. The Clavilithes series is also derived from a fusoid ancestor but a very different one from that which gave rise to the Clavellofusus series. If M. Cossmann will admit that my Clavellofusus series is a distinct series, — no matter what its origin, — and I do not see how he can do otherwise unless he abjures all regard for phyletic principles — I care not whether he joins me in calling it a distinct

[1] I shall throughout use the term mutation in the earlier sense of Waagen.

genus with species each showing a distinct step in progressive development, or whether he makes the whole series a variety of something and calls my species subvarieties. But he cannot make the series a variety of *Clavilithes parisiensis*, any more than he can make the uncle the son of the nephew.

Professor Boettger will probably find it difficult to point out that the difference between the protoconch of Clavilithes and that of Rhopalithes is due to any difference in physical environment, as the fusoid members of the series, *C. rugosus* and *R. rugoides* occur side by side, the same being true of other members of the same series as well. Moreover, if he agrees with Cossmann, that Rhopalithes and Clavilithes are generically identical, he will have to show why the series with the Fusus-like protoconch has columellar plaits and why these are wanting in the series with a papillose protoconch.

Finally I may again call attention to the fact that I have described in detail the variation in the protoconchs of Fusus and that I have readily admitted the possibility of the existence of larger and smaller initial whorls, of an increase or decrease in the number of whorls in the protoconch, and of the variation in the number of riblets on the protoconch. In fact I have illustrated such variations but I am not ready to admit that there is ever a difference of type in the protoconch in what can otherwise be referred to the same genus. I have repeatedly shown, that the so-called species of Fusus from the American Eocene strata not only disagree utterly as regards the type of the protoconch with true Fusus, but that the young stages as well show much more acceleration than is found in the young of even modern Fusus. "*Fusus apicalis*" and "*Fusus houstonensis*" are an exception to this and it is not impossible, that in spite of the remarkable protoconch, these may be more nearly related to true Fusi, than is either *Falsifusus meyeri* or *Fulgurofusus quercollis*.

Fusus aciculatus and "*Fusus*" *serratus* occur side by side in the Calcaire Grossier of the Paris Basin, yet the first retains its normal Fusus protoconch while the second has a widely different type of protoconch, like that of many Pleurotomas. It will be difficult to explain on the hypothesis of any local cause of variation why *F. aciculatus* retains the early Fusus whorls, common to all true

Fusus, and always associated with the Fusus protoconch, while "*Fusus serratus*" with a distinct protoconch has whorls more specialized than those of any other true Fusus, even those of the present day. Why do the fusoid shells in which the normal post-embryonic developmental stages of Fusus occur, always have a Fusus protoconch, while those fusoid shells which do not show the true Fusus protoconch do not show the normal ontogenetic stages of true Fusus, if this is not an expression of inheritance, and of more fundamental significance than Cossmann, Boettger, or Giard are welling to admit? It is high time that we cease making generalizations and tracing relationship by a superficial study of shell characters. Such superficial study has deservedly brought the whole subject of conchology into disrepute, so that morphologists have come to look upon shell characters as the least reliable indices of genetic relationships, whereas they are really the most reliable and delicate of such indices, if subjected to a critical study.

Elimination of Early Conch Characters by Acceleration.

It not infrequently happens that the protoconch stops abruptly, and the conch begins as abruptly. In fact, it may be said that this is normal for such specialized types as the fusoid shells (Studies I, figs. 1 and 5). In normal primitive types the protoconch characters may be expected to merge by slow degrees into those of the conch. Such is the case even in types specialized along one direction or another. In highly specialized types, however, we often find an abrupt transition from the characters of the protoconch to those of the conch, these latter beginning suddenly with a number of special characters. Thus in Fusus, the protoconch ends abruptly with a strong varix, and the conch begins with round whorls, ribs and spirals. Here protoconch and conch have been telescoped, so that the transitional characters undoubtedly possessed by the ancestors of this genus were dropped out. Conditions of this kind exist in a number of types which may or may not be related to Fusus. Such relationship of protoconch and conch cannot of course be regarded as indicating consanguinity wherever it occurs, for it is clearly a stage in development, and therefore a condition, which may appear in the specialized terminal

members of any number of divergent genetic series. Conversely, however, the want of such accelerated conditions in members of the same genetic series may well be regarded as sufficient for generic distinction, though this is largely a matter of personal opinion regarding the elasticity of the generic boundaries. Even greater acceleration than this is shown by many genera. Thus certain species of Semifusus have dropped out the round-whorled ribbed stage, the conch beginning with the angular stage (Studies I, Fig. 5).

In many cases the early characters appear not to have been wholly dropped, but greatly condensed, so that the protoconch quickly merges into a highly specialized conch, the transitional stages being extremely short and often scarcely recognizable. Then, too, some of the early stages may drop out without the abrupt change seen in Fusus, etc. Thus characters which in the phylogeny of the group were developed only at a relatively late period after other characters had come into existence, may in the specialized members of this series appear immediately after the protoconch, the earlier characters being dropped out of the ontogeny. On the other hand, certain persistent characters may be pushed far back into the ontogeny, and appear even in the protoconch stage. This is seen in the riblets of the last whorls of many protoconchs (Fusus) and in the appearance of an angulation or carina in others (certain Murices, etc.).

Not only is acceleration by condensation and elimination active in the earliest conch stage, but it is often found at a later period, where some shell character, not strongly fixed in the organization, may be eliminated to make room for a later and more prominent one. This condition has already been briefly described for Fulgur and Semifusus (Studies I, p. 932) and more fully for Fulgur in a later paper (Studies II, p. 528). It may be briefly reviewed here.

In both genera, and in the case of Pugilina in what are commonly regarded as varieties of the same species, the tubercles are normally developed as a result of the concentration of the ribs upon the shoulder angle. This is characteristic of the earliest Miocene Fulgurs as well as the ancestral forms of Semifusus and Pugilina. With further development the tubercles grade into a keel and this into a smooth rounded and ribless whorl, differing from the

primitive rounded and ribless whorl in the presence of compound spirals. This is the condition of adult *Fulgur maximum* and certain forms of *F. rapum* of the Miocene. In more specialized types a series of spines appears at periodic intervals on the primary spiral which originally marked the angulation of the shell (Fig. 7). These spines at first small, increase in size progressively up to a certain point. They are simple triangular emarginations of the outer lip and often are abruptly abandoned, so that they remain open forward, though in other cases they are closed in front showing a more progressive abandonment of the spine. This diminution of the spine-forming emargination, is generally more rapid than its development. This condition of newly added spines following in the last whorl upon a smoothly rounded or slightly keeled, non-tuberculate whorl is characteristic of *Fulgur tritonis* (Fig. 7), *F. pilosum*, and others where a fraction of one whorl to several whorls without tubercles or spines separate the primitive tuberculate, from the last spinose whorls (Fig. 7). The same is true of varieties of *Semifusus colosseus* and *Pugilina pugilina* of the modern fauna (Fig. 8). Finally in the most specialized types, such as *Fulgur carica, eliceans*, etc., and the accelerated varieties of *Pugilina pugilina*, the spines have been crowded back to such an extent that the non-spinose stages have been dropped out. This telescoping has gone so far as to result in partial overlapping of the spinous and tuberculose stages, as a consequence of which the tubercles pass insensibly into the spines. All stages of this telescoping can readily be observed in large collections of the recent species of Pugilina cited.

The significance of this telescoping of characters is often not appreciated. That it cuts out ancestral stages and shortens the ontogeny by this elimination is evident, as is also the resulting vitiation of the phylogenetic record in the ontogeny. Moreover such an overlapping of characters destroys their individuality to a certain extent and makes the later appear to be a mere accentuation of the earlier whereas they have a distinct origin. Such telescoping has apparently occurred in a great number of phyletic series. In Eocene Columbarium, for example, the tubercles grade into the spines in the nepionic stage of the shell. In modern *Columbarium pagoda* (Fig. 6) the tubercles and ribs have been pushed

out of the ontogeny altogether so that the angulation of the ribless whorls and the appearance of true spines is almost simultaneous. Yet the Eocene species indicate that the genus passed through a normal series of round-whorled-ribbed, and angular-whorled-tuberculated stages before the spines appeared. As already noted, a second row of spines appears in several lines of radiation in this series. In the genus Rhinocanthus, typified by *Murex* (*Rhinocanthus*) *brandaris*, the principal spine likewise merges with the tubercles which here are formed without the loss of the ribs. The second spine has also been accelerated until it appears during or shortly after the tubercled stage. In the more specialized Murices, where the adult spines are compound, the early ones have been pushed far back and are inseparable from the tubercles or even from the ribs. It seems in fact that the spine-forming stage has become superposed upon the rib-forming stage for the ribs are characteristic of adult Murices of such relatively simple types as *M. brandaris* and of such highly complicated types as *M. palmarosae* as well.

In tracing the phylogeny of spinous gastropods it must be borne in mind that tubercles and spines have a different origin, and that where they appear to merge into each other this is due to acceleration. It is highly probable that the ancestral forms of such types will be found to have these two characters separated, the spines not being found in the earlier members of the phyletic series as has been demonstrated to be the case in Fulgur.

As has been shown above, the ontogeny of a great many widely distinct types of gastropods is marked by a progressive increase in the amount of embracing of the earlier by the later whorls. This results in a change of angle of the spire from relatively acute in young to often a rectangle or obtuse in the adult. In some types (Conus) the change may be to 180 degrees, rarely more. This same change is observable in the adults of the successive members of the corresponding phyletic series. Thus the Eocene species of Fusus are characterized by a slender spire throughout, while the modern forms usually show the slender spire only in the youthful stages, the adults becoming more broadly turreted. In Tudicula, the Miocene species show a more slender spire, especially in the young, than is shown in the modern species. A similar

condition is observable in Turritella, where the early species are generally more loosely coiled. Such looser coiling is also observable in the young of modern forms, in the adult of which the whorls embrace up to the angulation. Here however another factor enters in, the progressive flattening of the whorls so that the spire remains slender even though the whorls embrace to the ambitus. Similar conditions obtain in Nerinea, Cerithium, and others, the surface of the whorls even becoming concave in many of these.

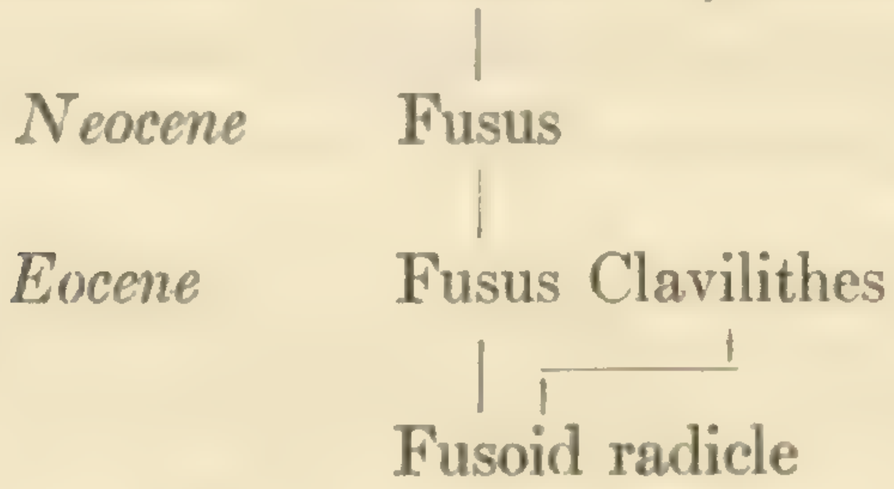
In its most pronounced form the progressive increase in the amount of embracing of the whorls is seen in phylogerontic types. Here this increase is accompanied by a loss of ornamentation and distinctive form. In its most striking form this excessive embracing is seen in Melongena, where the earlier whorls become to some extent enwrapped by the later ones, the form of these later whorls bearing no relation to that of the earlier ones, but being without the normal ornamentation of the earlier whorls (Studies I, fig. 9). Similar though more regular conditions are found in the clavilithoids for a discussion of which the reader is referred to my "Phylogeny of Fusus." Cossmann has recently reiterated his belief in the generic relationship of Clavilithes and Cyrtulus which latter type is a phylogerontic terminal of the modern Fusus series. This reassertion of his former position indicates that Cossmann has either not carefully read my arguments for the total distinctness in origin of these types — or if he did, that he does not consider them as valid. If this is the case I must give up all hope of convincing him, for I do not see that I can state the case more fully. If any one not biased by inherited ideas of relationship indicated by adult characters, will carefully compare the young of *Cyrtulus serotinus* Hinds with the nepionic and neanic stages of any species of Fusus of the *F. colus* series, he will be impressed with the similarity of these two types, a similarity which so far as the details shown are concerned, amounts to identity. I do not believe that any one can distinguish the young of *Cyrtulus serotinus* from that of any member of the Fusus series, unless he finds some characters not yet observed in these types. Certain it is, that the young of this species, is more nearly identical with that of any member of the *Fusus colus* series than with any other known gastropod. This similarity can only be the result of relationship, so that the unbiased

investigator will probably be forced to accept this evidence as indicative of community of descent. If we now take the most closely similar type of the Eocene clavilithoids, which I think all will agree is found in the forms I have classed as Clavellofusus — but which Cossmann still considers varieties of *Clavilithes parisiensis* Mayer-Eymer (*Clavella deformis* of Cossmann) we find that its young leads us to some Eocene or earlier fusoid ancestor which may or may not have been the ancestor of the modern Fusi, including the *Fusus colus* series as well. Assuming, for the sake of making the argument as favorable as possible to M. Cossmann, that Fusus and Clavilithes had a common ancestor,— which, moreover, is probably the case — and allowing for the moment that my species of Clavellofusus are varieties of *Clavilithes parisiensis* as Cossmann contends,— but which most certainly is not the case — if we allow this, where do we land? In the first place, if youthful characters show relationships at all,— and I doubt if in view of all the evidence accumulated along so many and diverse lines, even Cossmann will have the hardihood to deny this — it is evident that all the Eocene clavilithoids are derived from an Eocene or earlier fusoid ancestor, which we will allow was a true Fusus and the ancestor of the modern Fusus as well. Nevertheless, it remains true that *Cyrtulus serotinus* is a derivation of modern Fusus and not of Eocene Fusus, a point established beyond question by the character of its young.

If Cossmann were to contend that both the modern and the Eocene clavilithoids were derived directly from a common Eocene or earlier ancestor there would be some reason in his gathering all these divergent lines into a common generic boundary. The question would then be boiled down to that of the greater or less elasticity of the generic boundaries. But Cossmann holds that *Cyrtulus serotinus* is a descendant of Clavilithes ("quoiqu'elle [Cyrtulus] soit le descendant immédiat des Clavilithes") although the young stages show that this is not the case, as every student of phylogeny of Mollusca as deduced from shell structure will readily admit on comparison. Unless, then, Cossmann can prove the *direct* derivation of *Cyrtulus serotinus* Hinds and *Clavilithes*

[1] loc. cit. 1904, p. 234.

parisiensis Mayer-Eymar (or better *Clavellofusus spiratus*) from a common Eocene or earlier ancestor, without the intermediation, in the Cyrtulus line, of modern Fusus, his proceeding would be almost as illogical as the classification of all ammonoids showing a corresponding degree of involution in the same genus. This will appear more clearly from a consideration of the following diagram.



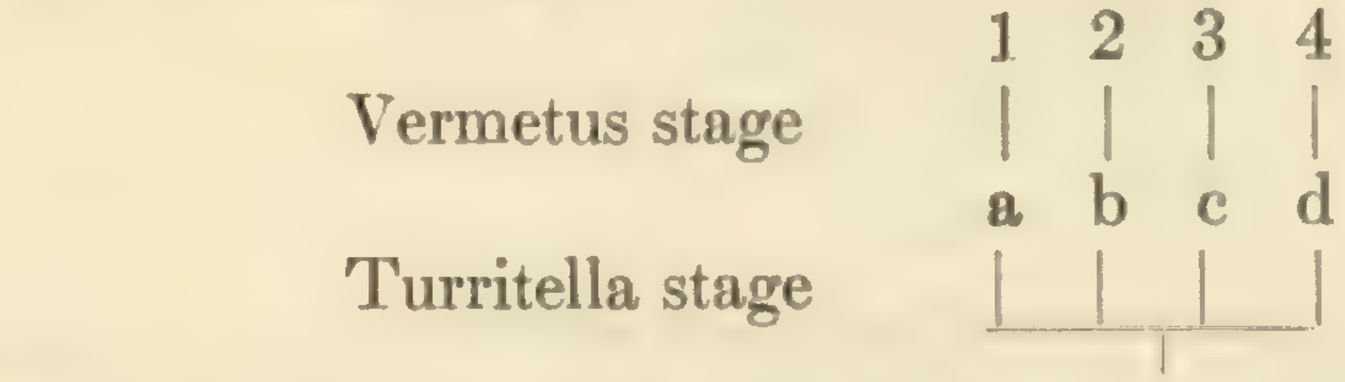
The only other way, in which Clavilithes and Cyrtulus can be made congeneric, is by also including Fusus in this genus, a stretching of generic limits, to which even M. Cossmann will most certainly object.

I have elsewhere[1] outlined in detail a number of genetic series among the Clavilithoids which, diverging probably from a common ancestor, produced similar end forms, just as divergent ammonite phyla often had end forms superficially alike. Whether the series which I have outlined to the degree of detail permitted by the available material, will be found to be complete, or will need modification in the future, remains to be seen. That the various series exist, is, I think, beyond cavil, and certainly cannot be set aside by a wholesale assertion of authority even on the part of the most veteran collector of these fossils.

It has already been outlined in the earlier part of this paper, that old age characters in gastropod shells are also shown by the loss of the power to coil, as is so commonly the case in cephalopods. That such characters have been taken as distinctive of new genera is not surprising, and indeed is desirable. Great caution however is necessary not to make this the sole distinguishing character, and class together terminal loose-coiling members of distinct genetic

[1] Phylogeny of Fusus. Smithsonian Miscellaneous Collections, vol. XLIV, no. 1417, 1904.

series. That this has been done in Vermetus, admits of little doubt. The Mesozoic and Tertiary species of this group represent phylogerontic terminals of various genetic lines of turritelloids, becoming extinct in these periods, just as modern species represent terminals of one or more lines of modern turritelloids. Even if the species of turritelloids are considered as congeneric throughout, the terminal vermetoids cannot be congeneric but merely represent a stage in development. Each terminal group would of necessity represent a distinct genus unless it were united in one genus with its corresponding ancestral turritelloid, as in the following diagram.



Thus if *a*, *b*, *c*, and *d* represent four diverging specific lines of Turritella and *1*, *2*, *3*, and *4* the corresponding Vermetus form, these latter could not be classed as one genus, Vermetus, unless *a*, *b*, *c*, and *d* were also classed in the same genus. Each must be considered as a separate genus whether it has one or more species, but *1* and *a*, *2* and *b*, *3* and *c*, *4* and *d*, can each be classed as a distinct genus, with a turritelloid and a vermetoid species, or all species of vermetoids may be classed as Turritella.

This reasoning applies with equal force to the non-coiling forms commonly classed as Platyceras, this term having the value of a stage. A similar though very slight loosening of the last whorl is made the basis for the separation of the genus Diastoma from Melania, although pathologic individuals of the latter sometimes show an identical character (Fig. 19). That in the case of this so-called genus we really deal with a stage in development, and therefore with terminal members of different phyletic series, which ought to be united with their respective Melania ancestors instead of being classed together, becomes more apparent as the detailed study of these types progresses.

In extremely accelerated series it often happens that the mode of development appears to be reversed, the specialized character appearing first, and the less specialized later. Thus in certain

Melanias in Cerithium, Turritella, etc., ornamentations appear in the young which are lost in the adult. Without departing from an orthogenetic mode of development, the succession of characters developed seems to be inverted. In such cases it generally appears on study of the youngest stages that the simple characters of the adult are similar to the most youthful characters, before the most pronounced features appear. This feature will be described later in some detail in certain Melanias and is also seen in other specialized types. It is readily explained by referring it to degradational development, where characters acquired during the aggradational period are lost in the reverse order of their acquisition. Sometimes differential acceleration may account in part for this. Thus in some cases, the shell becomes carinate and only subsequently develops ribs. These may be a later acquisition having never before appeared in the phylogeny of this series. Whatever the cause of such development, the method is orthogenetic, the variation being in all cases progressive in one direction or another.

Examples Illustrating Orthogenesis.

I have elsewhere described a considerable number of genetic series among the fusoid shells[1] and have also traced in some detail the development of the Fulgur and Sycotopus series (Studies II). It has there been clearly shown that the development is orthogenetic, both as regards phylogeny and ontogeny, and that the great governing principle in the production of diversity is acceleration or tachygenesis, and retardation or bradygenesis. To show more clearly the universality of this principle of orthogenetic variation among the Gastropoda, I will here append a somewhat detailed discussion of several phyletic lines among the Melanias, a group as distinct as possible from the Fusidae. Unfortunately in the specimens studied, the protoconchs were not available, so that all the deductions are based upon the characters of the conch, from its earliest to its latest stages.

Melania is well adapted to this sort of study on account not only of its variability, but also because it has so many characters upon

[1] loc. cit.

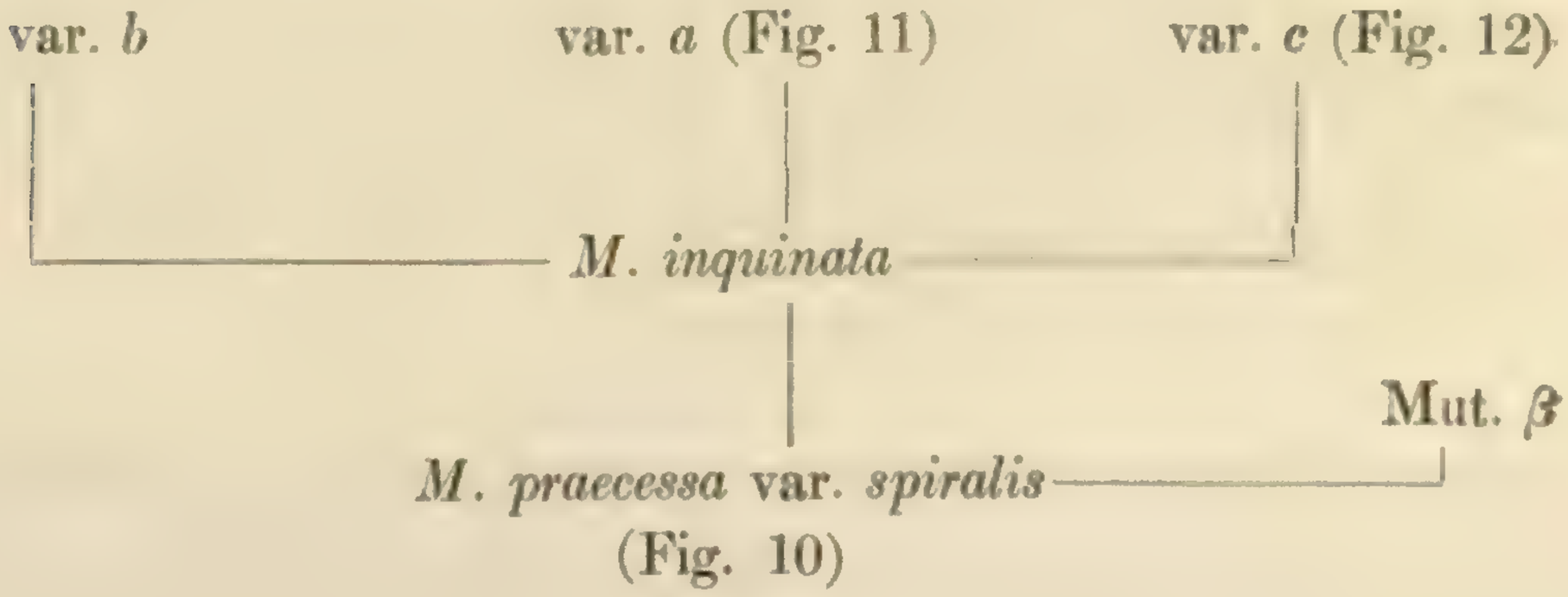
which we can seize for the purpose of determining the line of progress. The earliest types were undoubtedly marine giving rise on the one hand to the fresh water Melanias and on the other hand to a number of marine descendants. No exhaustive discussion is contemplated here, this and the tracing of the various genetic lines being reserved for a future work. Only some of the more salient features developed during the study of this group of shells will be mentioned here as illustration of the principles discussed.

The Eocene *Melanoides praecessa* and *M. inquinata* of the Paris basin may be taken as a starting point, though they already present characters of considerable complexity both showing a marked series of changes. In the former the earliest stages observed show rather flatly rounded whorls with distinct, narrow, rounded ribs which are concave forward (i. e., towards the aperture). These ribs are cancellated by revolving spirals which however are faint in the interspaces, but form pronounced nodules on the ribs. In some specimens the earliest ribs appear to be free from these tubercles, and the mode of appearance seems to indicate that the ribs precede the spirals. This is the character of the early stages of the type specimen figured and described by Deshayes (Des., An. sans. vert., II, p. 452, pl. 23, figs. 31–32) these stages being free from spirals. This character recalls the adult of *Pseudomelania* (*Chemnitzia*) *undulata* d'Orb., *Ch. carusensis* d'Orb., *Ch. corvaliana* and *Ch. periniana* d'Orb., from the Middle Lias and *Ch. rhodani* of the Upper Lias of France.[1] In later Jurassic strata of France occur many Pseudomelanias, which show no ribs in the adult. Some of these may however possess them in the young, as has actually been found in the case of *P. nerei* d'Orb. of the Bathonien. Such occurrences suggest that the smooth Pseudomelanias are derived from the ribbed ones and hence in so far as they have lost this character are phylogerontic.

In Eocene *Melanoides praecessa* var. *spiralis* var. nov. from Noyon (C. U. coll. 30041, fig. 10) the spirals become gradually strengthened, until they are well marked. The uppermost or posterior spiral becomes strongest; and gradually the space above it develops into a concave shoulder free from ribs. On this shoulder-

[1] D'Orbigny. Paleontologie Francaise.

angle develops a series of nodular spines, as the ribs gradually become obsolete, slightly fainter nodules being formed where the lower spirals and ribs cross. With the complete disappearance of the ribs, the lower spirals — of which there are four large and three smaller more closely crowded ones in the adult — become continuous and free from nodulations. No intercalated or secondary spirals occur, except in accelerated types, where the shoulder and nodules exist for only a few neanic whorls, after which they gradually disappear, only faint primary and secondary spirals remaining on the last whorl (Mut. *β* Fig. 9; C. U. coll. 30042). In the type specimen of *M. praecessa* figured by Deshayes, the ribs have not entirely disappeared in the adult. It represents a more primitive or more retarded individual than the Noyon variety described above, its adult features being comparable to the early neanic of var. *spiralis* Grabau. Three varieties of *M. inquinata* (Def.) are figured by Deshayes (Coq. foss. Em. Paris II pl. 12), of these var. *a* (Desh., figs. 3 and 14, our fig. 11) is the immediate successor of *M. praecessa* var. *spiralis*, but the tubercled character, which in that variety occurs only in the adult, is here found in the neanic and perhaps even in the nepionic whorls. Var. *b* (Desh., figs. 15, 16) is characterized by the suppression in the adult of all the spirals except the one on the angle, on which the tubercles become greatly strengthened, and the spiral just above the suture which is non-tuberculate. Both shoulder and body of the whorls become strongly concave in the adult. The third variety (*c*, figs. 7 and 8 of Deshayes) has all the tubercles suppressed, while the spirals become strong and the whorls below the shoulder rounded (Fig. 12). The phyletic relationships of these types may be expressed as follows, the length of line representing relative amount of divergence.



M. praecessa var. *spiralis*

|

M. praecessa
(Desh., An. sans Vert., II, pl. 23, figs. 31–32)

|

Jurassic ribbed Pseudomelania
(D'Orbigny, Pal. Francaise)

|

An interesting line of departure is shown in some specimens of *M. praecessa* var. *spiralis*. Here the second spiral from the posterior suture is the strong or primary one; *i. e.*, early in the ontogeny a new spiral appears above (posterior to) the primary one. This continues on the shoulder, and before the disappearance of the ribs becomes somewhat tuberculose. Intercalated spirals also appear on the adult whorl. This appears to have been the lineal ancestor of *Melania asperata* Lam. var. β Brot, of the Philippine Islands, a fresh water type (Figs. 14 and 15). The less accelerated individuals of this form show the early ribbed whorls, though these are marked by a large number of closely set extremely fine spirals not observed in the Tertiary species. In the individual represented by Fig. 15, a single row of spines makes its appearance after five or six volutions. These spines appear near the center of the exposed whorl, one on each rib, and begin shortly before the appearance of the ribs themselves (Fig. 17). At first the spines are very weak but gradually they increase in size, at the same time beginning earlier and ending abruptly upon the rib. Together the spines and their posterior prolongations produce the appearance of spirals. The single row of spines continues for almost four volutions the whorls gradually becoming divided into shoulder and body with the spines on the pronounced shoulder angle. A second row appears on the shoulder beginning as a faint elevation which is gradually strengthened.

In a more accelerated individual (Figs. 14 and 16), the second row of spines appears almost simultaneously with the first one though the lower row becomes somewhat more strongly accentuated.

Strong spirals appear on the body of the whorl without the formation of spines, one or sometimes two of these spirals appearing above the suture of the succeeding whorl. Intercalated spirals occur on the body of the last body-whorl.[1]

These Melanias therefore seem to be extremely accelerated, the spines appearing while the ribs are still in full force.

A type apparently retarded as far as the form is concerned is found in *M. dactylus* Lea from the Philippines (Martini Chemnitz Melania pl. 9, figs. 2 and 2a) in which two whorls of the adult are marked by narrow crescentic ribs cancellated by numerous spirals which appear in the earliest part of the ribbed whorls. The initial whorl is not known but the whorls immediately succeeding are smooth in appearance and embrace to the ambitus. Whether or not fine spirals occur on the earliest whorls is not ascertainable. The succeeding whorls embrace less, thus producing the slender spire. In the adult of many individuals the ribs become obsolete that being the usual line of development. Brot (Martini Chemnitz I 24, pl. 9, fig. 2a) however figures a specimen which successively acquires two rows of tubercles in the adult thus paralleling *M. asperata* var. β of the Philippines.

While these types show aggradational progression, modified by differential acceleration and retardation, other species referred to Melania show degradational progression, i. e., a progressive modification through suppression of characters. Certain Jurassic Pseudomelanias showing this have already been mentioned. A modern example is *Melania elevata* Say from Indiana. Here the late nepionic and neanic whorls are carinated, this carina gradually disappearing the shell becoming smooth and with scarcely impressed suture and with spirals only on the lower part of the whorl. The aspect is that of Pseudomelania, the character being derived through progressive reduction of features inherited from specialized ancestors.

The same thing is true of *M. deshaysiana* Lea, and *M. costulata* Lea from Tennessee. Here the order of development seems to be entirely inverted, the earliest whorls being carinated while the later ones show successive suppression of the carina, and the

[1] See Martini und Chemnitz, Syst. Conch. Cab. I 24 pl. 8, figs. 1, 1b and 1f.

strengthening of the ribs and spirals until in the spiral whorl the ribs and spirals gradually disappear. So far as shown by the specimens examined, which all lack the apical whorls, the ribs are absent from the early carinate whorls. It is possible that the carinate whorls are preceded by rounded ribbed whorls but of this we have at present no evidence. Should this eventually prove not to be the case, the explanation of these characters must be found in the early acceleration of the carina, which appeared on the smooth whorls before the ribs had appeared these latter not coming in until the time of disappearance of the carina. In *M. strigosa* Lea from the same locality, ribs seem to be wanting altogether, the early angular whorls passing by disappearance of the keel and spirals into a smooth adult form. Other species having smooth adult, and ribbed and spiralled youthful form are *M. rustica* Moussen (Martini Chemnitz pl. 17; 2 a, b), *M. palimpsestos* Reeve (Martini Chemnitz pl. 17; 3), and *M. hastula* Lea (Martini Chemnitz pl. 16; 3, a–d).

Claviger subauritus Brot represents the more primitive condition of that genus, in which the whorls are ribbed, the single row of tubercles being developed only on the last whorl (see Martini-Chemnitz I 24, pl. 36, fig. 11a).

The extremely spinose types of Melanias such as *Claviger byronensis* Gray (Martini Chemnitz pl. 36; 10a–c), and *C. auritus* Müller (Martini Chemnitz pl. 36; 7a–c), represent accentuations of one character at the expense of the others;— a one-sided acceleration. In the latter species the nepionic whorls show ribs and spirals the central of which become fused with two adjoining ones. This fused series quickly becomes accentuated in a pronounced tubercle, which increases in size and becomes variously modified while the remaining portion of the shell becomes smooth. At first the tubercles are near the middle of the whorl but gradually as they increase, the relative amount of embracing increases until the tubercles of the adult whorl lie just above the suture. In *C. byronensis* two groups of spirals become tuberculated, a third one occurring in some varieties.

A closely parallel series of variations is found in the modern *Potamides fuscatus* of Gambia. The nepionic and early neanic stages are identical with the adult of *P. granulatus* (Brug.) (*P.*

corvenii Fer.) of the same locality. This begins with a round-whorled ribbed stage passing into an angulated stage in which the spirals are prominent. The ribs progressively break up into tubercles, those on the median spiral being more prominent. In accelerated individuals (*P. radula* Linn.) the upper of the two median spirals has its tubercles slightly more accentuated than the lower, while a secondary spiral between them is also slightly tuberculated. The young of *P. fuscatus* Linn. shows the bicarinate whorls, the spirals forming the two carinae being tubercled. Somewhat later the upper series of tubercles becomes accentuated and a secondary spiral appears between the two. Up to this point, perhaps one fourth the length of the shell or less, all the stages except the earliest of *P. granulatus* are repeated, so that the young of *P. fuscatus* is in effect a diminutive *P. granulatus*. The further development of *P. fuscatus* is along the line of accentuation of the tubercles of the upper spiral, until they have become pronounced, sharp, and spine-like in the adult, all the other spirals, except the one just above the suture, disappearing in the most specialized examples. The series in this case is as complete as is that of the spinose Clavigers, and representative species, showing the same stage of development so far as the surface characters are concerned can be selected in both series.

The carinated Melanias represented by *Claviger matoni* Gray (Martini Chemnitz pl. 37; 3, 3a–f; 4, 4a–*b*) from Senegal show another interesting type of modification. The primitive species (*C. mutans* Gould, Martini Chemnitz pl. 37; 3b–e) are spiralled and ribbed, the upper spiral being the stronger. In somewhat more accelerated individuals the ribs are lost on the last whorl, but the spirals continue and become stronger, especially the upper one which begins to extend outward as a strong flange forming a deep notch or sinus in the lip. Somewhat more accelerated specimens show two or three final whorls in this condition, the flange of the last one becoming extremely pronounced, while one or in case of more loosely coiling individuals, two of the lower spirals also begin to be strengthened. Finally in extremely accelerated specimens, the ribbed and spiraled portion is restricted to the apical part, and it passes almost abruptly into a smooth shell on which the upper spiral makes a pronounced flange-like carina,

while the one just above the suture also becomes very pronounced. Sometimes this latter is prevented from taking part in the ornamentation of the shell by the close coiling of the whorls, the succeeding whorls crossing this spiral. (Martini Chemnitz, I 24, pl. 37, fig. 3–3a). Differentially accelerated specimens may have the flange pushed back into the ribbed portion; i. e. the flange appears before the ribs disappear. Then the flange is broken up into blunt vertically flattened spines which unite into a keel as soon as the ribs disappear entirely.

We have thus in the Melanias, a group of highly accelerated gastropods in which the spines,— a specialized feature, appearing late in the phylogeny of most gastropods — have become a dominant character, appearing before the ribs have disappeared. Many phylogerontic members of this group, forming terminals of genetic series, retain their ornamentation only in the young, the adults becoming smooth. In several lines extreme accentuation of certain characters at the expense of others has resulted in grotesque forms. All the characters, however, appear and disappear in a regular progressive manner both in ontogeny or individual development, and in phylogeny or the development of the genetic series. The Melanias therefore constitute an excellent group from which illustrations of ortho-ontogenesis and ortho-phylogenesis may be obtained.

PALÆONTOLOGIC LABORATORY
COLUMBIA UNIVERSITY

PLATE I.

FIG. 1.— *Tudicula bispinosa* Grabau; young individual, showing beginnings of second row of spines. (Col. Univ. Coll. 30045.)

FIG. 2.— *Tudicula rusticula* (Basterot); early stages enlarged × 10, to show looser coiling and gradual appearance of spines and angulation. (C. U. Coll. 30046.)

FIG. 3.— *Tudicula bispinosa* Grabau; a somewhat older individual than that shown by fig. 1. (C. U. Coll. 30047.)

FIG. 4.— *Tudicula bispinosa* Grabau; showing two rows of spines fully developed (C. U. Coll. 30048.)

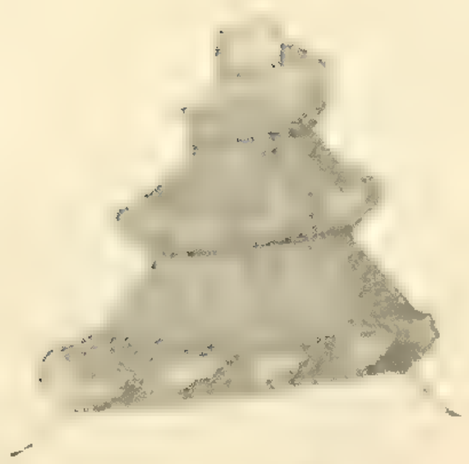
FIG. 5.— *Tudicula rusticula* (Basterot); a characteristic adult form with a single row of spines.

All the above are from the Miocene. Fahluns de Bordeaux.

FIG. 6.— *Columbarium pagoda* (Less.) Recent protoconch and early conch stages enlarged × 10, showing elimination of ribbed ancestral stages. (C. U. Coll. 39782.)

FIG. 7.— *Fulgur tritonis* Conrad. Summit view of a characteristic specimen, showing the smooth neanic stage and the gradual development of the spines. (C. U. Coll. 30052.)

1



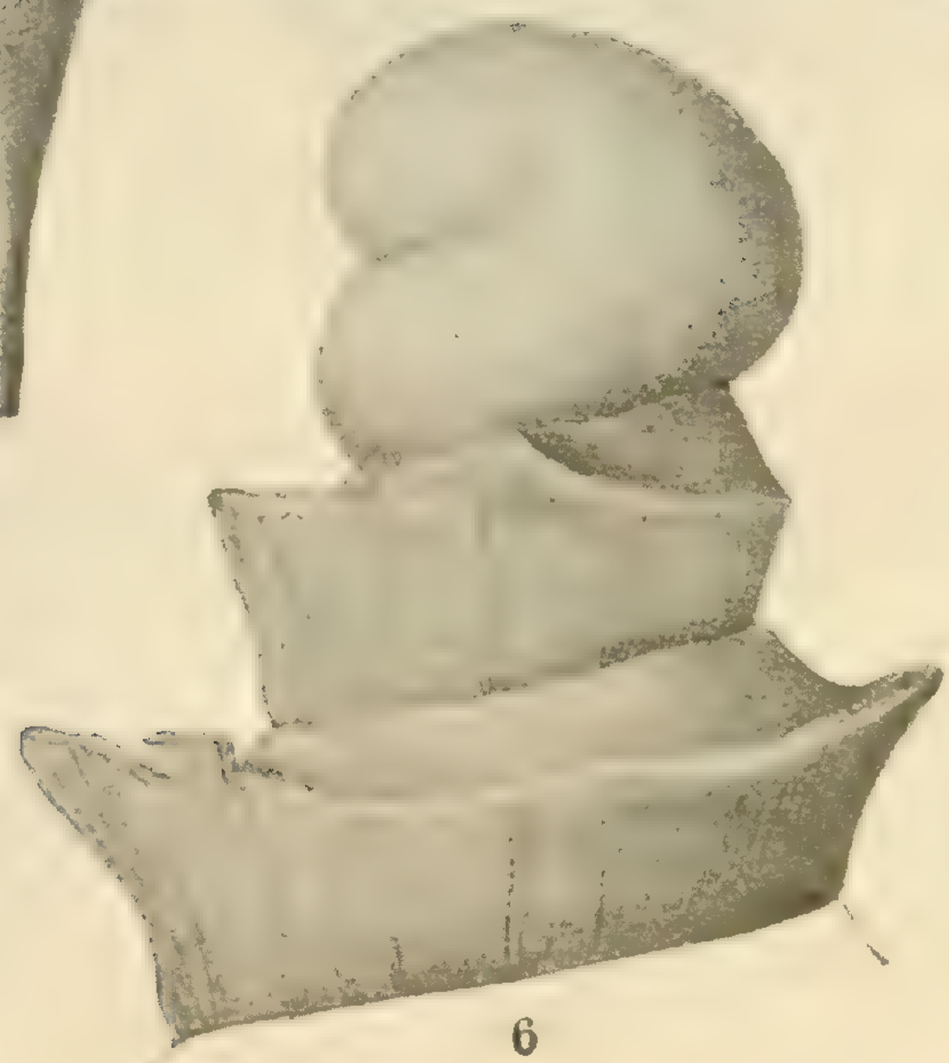
2

3

7

4

5



6

PLATE 2.

FIG. 8.— *Pugilina pugilina* (Born); a primitive mutation retaining the smooth stage in the neanic. (C. U. Coll. 39818a.)

FIG. 9.— ***Melanoides praecessa*** **var.** *spiralis* Grabau Mut. β; showing disappearance of nodules in later stages. Lower Eocene, Noyon. (C. U. Coll. 30042.)

FIG. 10.— *Melanoides praecessa* var. *spiralis* Grabau. Type. Lower Eocene, Noyon. (C. U. Coll. 30041.)

FIG. 11.— ***Melanoides inquinata*** **(Def.) var.** *a* Desh.— Copy of Deshayes figure.

FIG. 12.— ***Melanoides inquinata*** **(Def.) var.** *c* Desh.— Copy of Deshayes figure.

FIG. 13. ***Melania*** **sp.** An unidentified species from the Tertiary of Abyssinia showing appearance of second and later spirals, partly by intercalation. Much enlarged. (C. U. Coll. 30054.)

9

10

13

8

11

12

PLATE 3.

FIG. 14.— *Melania asperata* Lam. var. *β* Brot. Recent, Philippines. Accelerated mutation with two rows of spines appearing almost simultaneously. (See fig. 16.) (C. U. Coll. 41517.)

FIG. 15.—*Melania asperata* Lam. var. *β* Brot. Recent, Philippines. A mutation with a single row of spines in the young. (See fig. 17.) (C. U. Coll. 41518.)

FIG. 16.— *Melania asperata* Lam. var. *β* Brot. Enlargement of young stages of fig. 14.

FIG. 17.— *Melania asperata* Lam. var. *β* Brot. Enlargement of early stages of fig. 17.

FIG. 18.— *Melania* sp. An unidentified species from the Tertiary of Abyssinia showing appearance of third spiral by intercalation. Much enlarged. (C. U. Coll. 30053.)

FIG. 19.— *Melanoides praecessa* var. *spiralis* Grabau. A senile individual showing loosening of last portion of whorl, a feature regarded as characteristic of Diastoma. Enlarged × 2. Eocene, Bordeaux. (C. U. Coll. 30043.)

14

19

15

16

18

17

MUTATIONS AND THE GEOGRAPHIC DISTRIBUTION OF NEARLY RELATED SPECIES IN PLANTS AND ANIMALS

J. A. ALLEN.

In the *American Naturalist* for April, 1907 (vol. XLI, pp. 207–240) Robert Greenleaf Leavitt has discussed with great clearness and discrimination "The Geographic Distribution of Closely Related Species," with more special reference to plants than to animals, and also with reference to the bearing of the facts of distribution upon the mutation theory of de Vries. After presenting an impressive array of facts regarding the distribution of nearly related species, or "forms," in several widely different groups of plants, in part based on his own studies of the Orchidaceae, he gives his personal impression of the matter, stating in his concluding remarks that it seems to him "that the study of specific distribution in the vegetable kingdom is not likely to be unfavorable to Mutation, regarded as a method, but perhaps not the sole method, of evolution." He concludes: "The indications are that the adherents of Mutation will be able to bring forward enough cases of social distribution to render phytogeographic weapons useless in the attack upon this Theory."

Taking the facts of animal geography, as stated by a large number of zoologists, "we may say," says Leavitt, "that as a whole they militate against the operation of Mutation in a wide sense in the animal kingdom. This conclusion," he adds, "is not prompted by the attitude of certain of the zoologists mentioned ....but is drawn from the geographic evidence."

In his final generalizations he offers this very judicial statement: "First, we note that zoologists and botanists are rather distinctly opposed to each other in their views of the actual state of specific distribution. The suggestion is offered that zoologists may best discover the condition and interpret its meaning among animals, and botanists among plants. In no case is it safe to reason deduc-

tively from one kingdom to the other. In the factors affecting their evolution plants and animals differ vastly."

Here is a concession from the side of the botanists that should do much toward harmonizing the conflicting views of botanists and zoologists respecting the influence of 'mutation' in the evolution of forms among animals and plants. In the first place the conditions of reproduction, structure, growth, etc., in the two kingdoms are so radically different that the methods of evolution may also well be different; indeed, it would be surprising to find them not so.

Mr. Leavitt's paper is primarily a contention that President Jordan's law respecting the distribution of nearly related species does not hold in the vegetable kingdom. It is assumed that Jordan's law was intended to apply equally to both animals and plants, which interpretation seems to be supported by the context of the paper. The law is as follows: "Given any species in any region, the nearest related species is not likely to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort." If we substitute in this expression the word 'kind' or 'form' in place of 'species,' and restrict its application to animals, it will probably meet with general approval on the part of zoologists.

In testing Jordan's law by an examination of the facts of distribution presented by the Orchidaceae, Leavitt says he "looked for pairs of kinds," and adds: "I say kinds instead of species intentionally. The main problem should not be confused by the difficulty of agreeing upon a definition of species. What the evolutionist has to account for is not the definitions of systematists, but the multiplicity of hereditary types; he has to explain the antithesis between the uniformity which heredity seems at first to promise, and the diversity which actually prevails among organic things." It is evident, however, that in the expression "pairs of kinds," the term kinds is given unequal breadth of meaning in different instances, and is not here the equivalent of "nearly related forms," or "subspecies," as these terms are employed by zoologists. As regards the higher vertebrates, the evidence is indisputable that two closely related forms do not occupy the same area. By this expression the subspecies of zoologists are meant,— in other

words, intergrading forms of a common stock. It is therefore perfectly evident that botanists and zoologists are often speaking of entirely different concepts when discussing the occurrence or non-occurrence of species in the same area. It is also evident that minor forms among plants bear no relation to the minor forms among animals, either in mode of origin or in manner of distribution. In Crataegus, Rubus, Amelanchier, Viola, Aster, and countless other generic groups of plants, there often occur many slightly differentiated forms growing side by side over large districts. Among animals, at least among vertebrates, no such conditions appear to obtain; the slightly differentiated forms occupy different areas, and where the borders of their breeding ranges approach they gradually merge the one into the other with the gradual change in the environment. In the case of the plants mentioned, these slight differentiations maintain themselves despite similarity of environment; in the case of the animals, they are obviously the product of environment. The origin of such plant forms may never be discovered, but to many minds their development by mutation may seem not improbable. So long as we do not find similar conditions among the higher animals, it is hard to see how mutation has been active in the origination of new forms, whether species in the usually accepted sense, or the minor variants usually recognized as incipient species or subspecies. With these facts and conditions in view Dr. Leavitt's above-quoted suggestion that "zoologists may best discover the condition and interpret its meaning among animals, and botanists among plants," is eminently worthy of serious consideration. It is "obviously unsafe," as he well says, to reason deductively from one kingdom to the other.

A recent re-reading of the various recent papers by botanists and zoologists on the subjects of "mutation" and the "distribution of closely related forms" in animals and plants has given me the impression that much of the opposition of views on these questions is due in part to too sweeping assertions by both botanists and zoologists, in part to a misunderstanding by one side of what the other side really means, and largely to deductive reasoning from wholly dissimilar conditions.

AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK

NOTES AND LITERATURE

SCIENTIFIC EXHIBITS AT THE SEVENTH INTERNATIONAL ZOOLOGICAL CONGRESS

From the 19th to the 24th of August, American scientists were privileged to entertain the delegates and members of the International Zoological Congress at the Harvard Medical School, in Boston. The congress met in ten sections, and its program announced the titles of three hundred papers. The scientific exhibits, which were of unusual interest, are briefly described in the following paragraphs.

Paleontology.— Professor A. W. Grabau of Columbia University exhibited five series of spirifers of the *S. mucronatus* type, to show the gradual evolution of five species along parallel lines. The most primitive and oldest forms, from the middle Devonian (lower Hamilton), are long-winged and flat. They gave rise to the five independent series under discussion, in each of which the shells range from long-winged flat forms to those which are short-winged and round. Progress is always toward the rounded form, as shown both by the dimensions of the average shell in a given group, and by the extreme variations. Thus the most elongated shells in any group are not as long as the extreme examples from a lower horizon, but the most rounded forms surpass any which occur in the deeper strata. As shown by the lines of growth on the shells, the young stages in a given series are more elongated than the mature forms, thus resembling the adults of the preceding type. Thus the series demonstrates a gradual orthogenetic development of species, which, since similar changes occur in different localities, is presumably independent of environment.

Professor W. Patten of Dartmouth College exhibited a superb collection of Bothriolepis from the Devonian of New Brunswick. Bothriolepis is a fish-like invertebrate about ten inches long, consisting of an oblong cephalo-thorax covered with sculptured dermal plates, and a slender body free from scales but bearing dorsal and caudal fins. A strong, spine-like swimming appendage projects from either side of the thorax. Professor Patten has described and figured Bothriolepis in the *Biol. Bull.*, 1904, vol. 7, p. 105–124, and the related Trematapis in the *Amer. Nat.*, 1903, vol. 37, p. 223–242.

Bothriolepis presumably lived in fresh or brackish water, and moved in large schools. One of the slabs showed some ten individuals headed in the same direction. Ferns and plant stems turned in the opposite direction showed that they were moving against the current. Another slab contained four specimens moving in the same direction but lying at different levels, indicating that two at least were buried in the sand when killed. The internal structure of Bothriolepis, including its stomach and the arrangement of its gills, was shown in serial sections of the fossils. In studying the ancestry of vertebrates Professor Patten desired further knowledge of Bothriolepis than could be supplied from any existing collection, and therefore he collected for himself the group of fossils exhibited. His theory of vertebrate development from arthropod prototypes was illustrated by some fifty clay models. They were designed "to show how the earlier vertebrate stages are but a further specialization of the later stages of an arachnid. The models show the origin of the blastopore, the unfolding of the cranial sense organs, the relation of the cranial neuromeres to the cephalothorax, the origin of concrescence, the derivation of the operculum and branchial chambers, the lateral fold, visceral arches, and the union of the anterior visceral arches on the haemal side to form the premaxillae, maxillae, and mandibles." One series of models illustrated the relation between echinoderm larvae and arthropod half-embryos; another series showed similarities in the mode of attachment of the larvae of cirripeds, echinoderms, and vertebrates; and a third presented a suggestive comparison of the brains of the scorpion, horse shoe crab, and primitive vertebrate.

Dr. C. R. Eastman of Harvard University showed specimens of the head shields of lung fishes, so that the well known Scottish Devonian form could be compared with the less known Canadian Scaumenacia, and also with existing lung fishes.

Mr. C. H. S. Sternberg of Lawrence, Kansas, who has collected fossils for forty years, exhibited some tortoises from the Cretaceous "Red Chalk" of Kansas, together with a specimen of *Hesperornis regalis*. The latter does not include the skull, but the cervical vertebrae were found, and show that the bird had a longer neck than some have supposed. The skeleton of the feet and legs is complete and the pelvis is well preserved. The divergent position of the legs is similar to that seen in divers and loons. Mr. Sternberg is about to publish a popular account of his experiences as a collector, entitled "The Life of a Fossil Hunter," for which Professor H. F. Osborn has written an introduction.

Zoology.— Dr. C. F. Rousselet of London exhibited fifteen slides of rotifers. They were remarkably fine, since by a special method the animals had been preserved in an extended condition. They were killed in a $\frac{1}{10}$% aqueous solution of osmic acid, and sealed in 7% formalin on hollow ground slides. During the congress Dr. Rousselet identified fifteen species of rotifers which he obtained in one "dip" from the pond in the Public Garden.

Professor J. A. Thomson of the University of Aberdeen showed new and rare forms of corals chiefly from the Indian ocean. They included a specimen of the remarkable new genus Studeria from the littoral region of the Andaman Islands.

Miss E. R. Gregory, professor of biology at Wells College, New York, demonstrated the structure of the sand dollar, Echinarachinus.

Drs. F. B. Sumner and J. W. Underwood have studied "the seemingly protective coloration of the gastropod *Litorina palliata*" at Woods Hole, and they exhibited water color drawings, made by K. Hayashi, of the shells and the sea weed upon which they live. The shells vary from dark brown or black to bright yellow, and they may be either uniform in color or striped. The sea weed also ranges from dark brown to yellow. The snails, however, do not select appropriate backgrounds, either experimentally or in nature. Over variously painted sectors of a glass dish their distribution is purely by chance, and in nature yellow shells are found on brown weed and vice versa. As far as experiments have shown, the fish called tautog is as likely to take shells from the surroundings which they match as from others. It is possible, as has been suggested for other forms, that the pigment of the shells is the assimilated pigment of the weeds and matches them accordingly. Dr. Sumner's work is still in progress.

Professor W. C. Curtis of the University of Missouri demonstrated specimens showing the formation of segments in the tape worm *Crossobothrium laciniatum*, which occurs in the sand shark. Usually in tape worms new segments are formed near the anterior end, so that the most anterior segment is the youngest and the most posterior is the oldest. This is true of *C. laciniatum* until about 35 segments have been produced. Then, in the unsegmented region immediately behind the head, a new series appears, of which the most anterior is the oldest and the most posterior is the youngest; thus the body is segmenting from both ends toward a middle portion. When 50 anterior segments and more than 400 posterior segments have been formed the unsegmented middle portion is obliterated. After many of the posterior segments have become mature and been detached,

the neck region elongates, and a new set of segments may be produced, consisting like the first set of an anterior and a posterior group of segments. An account of this investigation was published in the *Biological Bulletin*, 1906, vol. 11, p. 202–229.

Professor R. Heymons, curator of the zoological museum in Berlin, showed several larvae of a beetle of the genus Tenebrio which had macroscopic rudiments of wings,—a pair on the mesothorax and metathorax respectively. Since the larvae were not reared, the time of the first appearance of the rudiments was not determined. It was observed that small rudiments were shed in molting but that the larger ones remained and finally expanded into the wings of the adult. External wing rudiments on larvae of insects undergoing complete metamorphosis are very rare. They have been observed in a few other coleopterous larvae (*Anthrenus varius*) and are probably "instances of premature development."

Dr. F. E. Lutz of Cold Spring Harbor exhibited specimens of the fly Drosophila, showing variations in the venation of its wings. The arrangement of the veins in wings of flies is usually quite constant. A disturbance of the normal arrangement sometimes occurs in Drosophila in nature, and by breeding selected individuals the disturbing factor has been increased. It is inherited somewhat, but not absolutely, in Mendelian fashion, and appears to be independent of environment.

Dr. S. Metalnikoff of the Imperial Academy of Science, St. Petersburg, showed sections illustrating the immunity of the moth *Galleria melonella* to the bacilli of tuberculosis. An hour and a half after injection, the bacilli were found within the blood corpuscles, and the remains of bacilli were detected in the corpuscles five days after injection. The bacilli become transformed into brown pigment. In the tissues the bacilli were found encapsulated three days after injection; a week later they were nearly all transformed into pigment. Finally the brown pigment is absorbed by the pericardial cells.

Mr. J. H. Emerton of Boston exhibited a large and well mounted collection of spiders, preserved in small vials of alcohol. The vials containing the forms and sexes of one species were attached to a large card, upon which were notes, drawings, and usually a photograph of the web. Many of the notes and drawings have been published in "The Common Spiders of the United States" (Ginn & Co., 1902),—an attractive introduction to the study of these arachnids.

Dr. A. Petrunkevitch of Short Hills, New Jersey, demonstrated the image-forming capacity of the lenses of spiders' eyes. The

integument of a *Lycosa nidicola* was removed, carrying with it the eight eyes. From the under surface of the preparation the retinae and vitreous bodies were brushed away, leaving only the lenses in position. The integument and lenses were mounted upon the stage of a microscope, beneath which a postal card was placed upon the table. With a $\frac{2}{3}$ inch objective, eight magnified inverted images of the McKinley portrait could be seen so distinctly that the surrounding inscription was legible. The vision of the spider depends, however, upon its retina and central nervous system. A preparation of the retina was exhibited to show the coarseness of the rods. Since an image which is so small that it falls upon only one rod would be perceived as a point, Dr. Petrunkevitch has calculated the distance at which a spider can possibly recognize another spider, and in other ways has studied the nature of spiders' vision.

Professor E. L. Mark of Harvard University exhibited live Amphioxus from Bermuda. They are nearly transparent creatures about two inches in length, which remain buried in the coarse shell sand with their anterior ends projecting slightly from the surface. If disturbed they dart through the water with the greatest rapidity and by a wriggling motion promptly disappear in the sand. It was noted that about the British Isles and in the Mediterranean, Amphioxus inhabits sand of a similarly coarse texture.

Professor H. F. Nachtrieb of the University of Minnesota demonstrated several features of Polyodon, the spoon-bill sturgeon. The "bill," or flat anterior prolongation of the head, contains a central cartilaginous axis and two layers of a network of bony spicules, the spicules being easily separated in potash. Nerves extend along the axis and radiate peripherally to the skin, and especially to the primitive pores. These are clusters of pits surrounded by the patches of pigment which give the bill a mottled appearance. Dissections of the bill and sections of the pores and pigment cells were shown. The variations in the lateral line were indicated in dissections and photographs, and it was noted that the lateral line extended out on the dorsal lobe of the tail nearly to its tip. It was formerly thought to end nearer the base of the tail, as in other fishes. Professor Nachtrieb is studying further the innervation of the lateral line.

Professor W. A. Locy of Northwestern University exhibited dissections of Scyllium, Trygon, Raja, and Pristiurus to show the nervus terminalis. This is a ganglionated nerve situated near the olfactory nerve and passing to the olfactory region. It was discovered by Professor Locy, and has been described in twenty-four genera of

selachians and in lung fishes. It is considered to be a primitive nerve belonging with the morphological tip of the body, which has been replaced in the higher vertebrates by the development of adjacent nerves.

Mr. C. W. Beebe of New York exhibited bird skins to show the changes in color produced by exposing a bird to excessive humidity during successive molts. The spots of a wood thrush become larger and darker. The breast of the white-throated sparrow becomes slate-colored and the entire bird is abnormally dark. The feathers of the Inca dove become black-edged, and the bird passes through a stage resembling the normal scaly dove to a dark condition which is unknown in nature. It has been generally recognized that birds are darkest in humid regions and palest in arid regions, thus forming numerous subspecies.

Dr. J. A. Allen of New York showed a series of skulls of Sinaloa deer collected within a radius of twenty-five miles. They presented extraordinary variation in the premaxillary, maxillary and nasal bones, which was not correlated with age or sex. A series of skulls of peccaries showed variations in the orbital region believed to be due to parasitic insect larvae. The skulls had not been examined when fresh so that the presence of parasites was not determined. The bilateral symmetry of the modifications of the orbit led some to question their parasitic origin.

Professor B. G. Wilder of Cornell University exhibited photographs of human cerebral convolutions.

Embryology.— Dr. J. Warren of the Harvard Medical School showed a series of eighteen wax reconstructions of the pineal region in Necturus, Lacerta, and Chrysemys. In all of these forms the paraphysis develops as a median outpocketing from the roof of the brain, anterior to the pineal body. In the adult Necturus the paraphysis is a macroscopic gland-like organ, consisting of anastomosing tubules between which are sinusoidal vessels derived from the sagittal sinus. Dr. Warren's models of the developing and adult paraphysis in Necturus have been described in the *American Journal of Anatomy*, 1905, vol. 5, pp. 1–28. His study of the paraphysis in reptilian embryos is not yet complete.

Professor R. J. Terry of Washington University, St. Louis, exhibited a reconstruction of the pineal region in the toad fish, *Opsanus (Batrachus) tau*. The general topography of this region corresponds closely with that of selachians (*Squalus acanthias*) but the paraphysis, which is well developed in the latter, is indicated in Batrachus only by a slight irregularity in the roof of the brain.

Professor Terry showed also a wax reconstruction of the skull of a cat embryo of 23.1 mm. This model, which is beautifully constructed, is of special interest in comparison with other similar models of chondrocrania,— Professor Gaupp's model from Lacerta, Dr. Tonkoff's model from the chick, and Professor Hertwig's model from a human embryo of 8 cms.

Professor J. W. van Wijhe of the University of Groningen, Holland, has perfected a method of making embryos transparent after a deep selective staining of their cartilages with methylene blue. The resulting preparations show the cartilaginous skeleton as clearly as the familiar transparent potash-glycerine preparations reveal the bony skeleton. This new and valuable method was used in demonstrating the development of the chondrocranium of birds, twenty specimens of which were shown under two inch objectives.

Professor W. A. Locy showed the aortic arches in chick embryos injected with ink while the heart still pulsated (a method devised, we believe, by Professor Mall). The embryos were then dissected so that the fourth and pulmonary arches were clearly shown, together with the small subdivision of the latter, which is described as the fifth arch. This fifth arch was the object of the demonstration. Its small size as compared with the other arches was evident, yet in the chick it is presumably a larger vessel than in mammals.

Professor S. H. Gage of Cornell University has obtained the glycogen reaction to iodine in sections of the medullary plate of Amblystoma, and also in nerve cells and in the deep layer of the retina in young lampreys. These tissues, which were exhibited, are additional examples of the wide occurrence of glycogen, especially in embryonic tissues, which Professor Gage has already demonstrated.

Professor Wilder showed the "smallest known embryo of the manatee," — a specimen approximately an inch and a half long.

Dr. J. L. Bremer of the Harvard Medical School exhibited reconstructions of the brain, pharynx, and liver of a human embryo of 4.0 mm. The brain is of particular interest since the neuropore is still widely open. In other human embryos of similar dimensions it is nearly or quite closed. This indicates either considerable variability in the time of closure, or that this embryo is abnormal. It presents, however, no other evidence of abnormality so far as is known.

Dr. F. W. Thyng of the Harvard Medical School exhibited wax reconstructions of the pharynx, stomach, pancreas, and cervical region of a human embryo of 13.6 mm. The jugular lymph sacs were modelled, probably for the first time in a human embryo. They

correspond essentially with the jugular sacs of the pig, rabbit, and cat. Each sac apparently communicates with the veins by a remarkably small opening which was not shown in the model. Dr. Thyng exhibited also models of the dorsal and the ventral pancreas in the rabbit, cat, and pig, one model of the latter including a well developed accessory pancreas.

Professor T. G. Lee of the University of Minnesota was the first to study the implantation and early development of the Sciuromorpha, the suborder of rodents which includes squirrels, chipmunks, prairie dogs, and gophers. Representatives of the other three suborders of rodents have been studied by other investigators. The Sciuromorpha have a characteristic early development. Before the placenta has formed, the vesicle acquires a temporary uterine attachment by means of a knob-like proliferation of cells on its ventral surface. *Geomys bursarius*, the pocket gopher, which belongs to a distinct family, perforates the epithelium of the uterus and develops in the uterine connective tissue. The aperture in the epithelium does not become closed as in the guinea pig, nor plugged as in man, so that Geomys is said to differ "in certain respects from any other mammal yet described." It may be noted that in the syncytial covering of the vesicles of all the Sciuromorpha the cells divide only by amitosis. Professor Lee exhibited a few of the interesting sections from his extensive series.

Dr. M. Herzog of Chicago has studied a very young human embryo in process of implantation. The sections exhibited were similar to those figured by Dr. Peters in 1899 as "the earliest known stage of human placentation." Because of their good condition and the rarity of such early stages, they are of great interest. The material is unquestionably normal, since it was obtained from the autopsy upon an individual who was accidentally and almost instantly killed upon the street; for such material it is unusually well preserved. Dr. Herzog has completed the study of the chorion and will soon finish that of the embryonic area and its appendages. The results will probably be published in the American Journal of Anatomy.

Cytology.— Dr. F. E. Botezat of the University of Czernowitz, Austria, was the first to demonstrate the presence of taste buds in birds. They were previously known in all other classes of vertebrates. His preparations of taste buds in the hard and the soft palate of *Passer domesticus* were shown by Dr. Gudernatsch. Preparations of Vater-Pacinian and Merkel's corpuscles from the tongue of the sparrow were also shown, demonstrating the neurofibrillar net and the end plates.

Dr. J. F. Gudernatsch of the University of Czernowitz exhibited sections of taste buds in the dugong. In the back part of the tongue there are certain large glands, the ducts of which expand into cup-shaped cavities near their outlets. In one of these cups there may be two or three elevations pitted with taste buds. The taste buds also occur occasionally along the deeper portion of the ducts. There are no vallate papillae, and no taste buds are found in connection with the small form of lingual glands. In the three orders of aquatic mammals taste buds are either absent, as in Cetacea, or they are not well developed, as in the Pinnipedia and Sirenia.

Professor S. Apáthy of the University at Klausenburg, Hungary, showed three series of cytological preparations, and demonstrated some ingenious devices used in making them. The perfection of his technique, as well as the nature of the specimens, made this one of the most notable exhibits. The first series of slides was produced by an unintentional experiment on living muscle nuclei of the leech Pontobdella, and showed important features of nuclear structure. The experiment consisted in injecting corrosive sublimate between the muscle layers of the intestine, instead of into the intestinal cavity, as was intended. The introduction of the cannula caused the nuclei to be compressed at one end and stretched at the other; in this condition they were immediately fixed by the reagent. In the normal nuclei the chromatin is arranged in coarse masses or knots at the angles of the nuclear network. In the stretched nuclei the network gave place to a series of parallel fibrils without cross connections, suggesting those of mitosis, and indicating that the network of the resting nucleus may consist of bundles of interlacing but unbranched fibrils. At the same time the chromatin knots were shown to be collections of granules rather than solid masses, for they had apparently disappeared by becoming evenly distributed along the fibrils. No nuclear membrane was seen, and Professor Apáthy believes that with few exceptions, the better preserved the specimen, the less definite is the nuclear membrane. In smears, nuclei may become distorted somewhat like those exhibited.

The second series of preparations dealt with Krause's membrane, the narrow dark line which bisects the light band of striated muscle fibers. Professor Prenant at one time believed that Krause's membrane occurred only in the muscles of arthropods and vertebrates; later be found it in Pecten and Sagitta but failed, after repeated attempts, to detect it in Salpa. Professor Apáthy demonstrated it very clearly in *Salpa maxima*, and showed it in the coelenterate

Carmarina hastata. He believes that it occurs in all striated muscle fibers.

The third series of preparations was of neurofibrillae, which were shown with astonishing clearness. The coarse fibrils of the invertebrate nerve cells (from Pontobdella and Lumbricus), the finer fibrils of the young dog, and the much finer fibrils of the adult suggest that a subdivision of the fibrils accompanies the perfection of the nervous system. The presence of neurofibrils is, for Professor Apáthy, the essential feature of a nerve cell. All cells have the property of contraction and of conduction, but they are not muscle cells unless they possess myofibrillae, nor nerve cells unless they contain neurofibrillae. It remains to be determined whether the development of neurofibrillae accompanies the outgrowth of processes from the neuroblasts.

Professor R. G. Harrison of Yale University showed drawings of the nerve cell processes sent out by detached cells of the spinal cord of a tadpole. The portion removed was examined in lymph, into which the processes grew, each having at its distal end a group of slender, radiating, amoeboid branches. At times these changed their shape more rapidly than could be drawn. Sections showing similar terminal branches were exhibited. In embryos from which the neural crest had been removed, nerves without sheath cells were produced, thus proving that nerve fibers may grow without the participation of sheath cells, and that the latter are derived chiefly from the neural crest.

Professor H. V. Neal of Knox College, Illinois, showed preparations of embryos of Squalus, demonstrating the outgrowth of processes from the neuroblasts. These processes could be traced for some distance through the surrounding tissue which took no part in the formation of the nerve fiber. The specimens showed indications of neurofibrils at an early stage.

Professor A. Maximow of the Imperial Medical Academy of St. Petersburg exhibited preparations of rabbit embryos to show the formation of the blood corpuscles. In the area vasculosa of a rabbit of 8½ days, only one form of corpuscle occurs; it is known as the primitive blood cell, and gives rise both to lymphocytes and to primary erythrocytes. These two forms of corpuscles are all that occur in the wall of the yolk sac at 9½ days. The primary erythrocytes are large cells derived from those which constitute the blood islands. Their formation soon ceases, and they gradually disappear from the circulating blood, in which only few remain at 20 days. Thus they are a purely embryonic type of corpuscle. The lymphocytes likewise

first appear in the yolk sac, but later they are formed from the endothelium of blood vessels within the embryo. A section of the aorta of a rabbit of 10 days and 5 hours showed a rounded mass of lymphocytes projecting into its lumen and still connected with its endothelium. The lymphocytes give rise to other lymphocytes and to the permanent erythrocytes. The latter are smaller than the primary erythrocytes; they are formed from lymphocytes throughout life, and ultimately, by the extrusion of their nuclei, they become the red corpuscles. In the vessels of the yolk sac at 12 days there are three kinds of corpuscles, namely primary erythrocytes, lymphocytes, and permanent erythrocytes. In the mesenchyma around the medullary tube of the embryo of 12 days, two small wandering cells were shown. These cells arise in the mesenchyma; in the bone marrow they come from cells like lymphocytes in the periosteal mesenchyma. The giant cells of the marrow were classed with the lymphocyte series.

In addition to these preparations Professor Maximow showed two others of much interest. One of these was a section of the thymus of a rabbit embryo of 15 days. The solid epithelial masses were being invaded by lymphocytes; the epithelial cells were not becoming deceptively similar to lymphocytes as has recently been stated. The other preparation was from a rabbit's kidney which had become atrophic, following the ligation of the renal vessels. In the kidney calcification and bone formation had occurred, and a well defined macroscopic area of bone marrow had developed. The remarkable development of bone marrow in the kidney always occurred in rabbits, but never in other animals similarly treated.

Mme. W. Dantchakoff of St. Petersburg demonstrated the formation of the blood corpuscles in the chick. A section from an embryo incubated 68 hours, showed cells similar to lymphocytes both within and outside the vessels overlying the yolk. The endothelium seemed to have formed among cells of one sort; those inside the vessels become lymphocytes and red corpuscles, and those outside become polymorphonuclear leucocytes. The differentiation of the cells was shown in a specimen of 104 hours incubation, in which eosinophilic granules were clearly seen in the cells outside of the vessel walls. A distinction between primary and permanent erythrocytes was not established by Dr. Dantchakoff in the chick. Other features, including the proliferation of endothelial cells of the aorta (shown in a specimen of 72 hours incubation), agreed essentially with Professor Maximow's demonstration of the rabbit.

Miss K. Bonnevie, of Christiana, Norway, exhibited preparations

illustrating the nature of heterotypical mitosis and showing that its significance in reduction divisions has been overestimated. Heterotypical chromosomes were demonstrated in the first cleavage division of Nereis. In the second maturation division of Amphiuma and in the first cleavage of Thalassema, cross-shaped chromosomes were shown. Cross-shaped chromosomes or tetrads are therefore not limited in Thalassema to the first reduction division. The tetrad shape was shown in some of the chromosomes of Nereis in metaphase fifteen hours after fertilization. A longitudinal splitting of the daughter chromosomes was shown in a cleavage mitosis of Nereis and also in its second maturation mitosis. Other features of chromosome structure which were demonstrated, include the spiral coiling of chromosomes in Amphiuma and Ascaris, and a spiral chromatic thread wound around the surface of each chromosome in the root tip of Allium. The relation of chromosomes to the resting nucleus was illustrated, and new chromosomes were said to arise within the disseminated chromatic material of the old ones.

Miss A. M. Lutz of Cold Spring Harbor showed sections of the root tips of *Oenothera lamarckiana*, its mutants and hybrids, to demonstrate the variations in the number of somatic chromosomes. The material appears very favorable for the counting of chromosomes, and it was remarkably well preserved and clearly stained. Nevertheless the question of one chromosome more or less in a given count is sometimes very difficult to determine. To the counts which have been made and were demonstrated by Miss Lutz, those recently published by R. R. Gates from somatic cells of the flowers may be added; their counts are as follows,— *Oenothera lamarckiana*, pure bred, 14 chromosomes (14, Gates); *O. nanella*, 14 in some plants, in others probably 15; *O. rubrinervis*, open pollinated, 14; *O. lata*, 14 in one plant, 15 in another (14 with "no indication whatever that the number is ever higher," Gates); *O. gigas*, 28 with a suggestion of a 29th in several instances, but 29 were never demonstrated in pure bred tissue; *O. lata* (hybrid) ♀ × *O. gigas* (pure) ♂ showed 21 in one plant, 22 or 23 in another, and 28 or 29 in a third. In the last case, if each parent supplied one half of its normal number of chromosomes, 21 or 22 should occur in the hybrid and this was observed in two of the plants. In hybrids produced by pollinating *O. lata* with *O. lamarckiana*, Gates has found 20 or 21 chromosomes. From these interesting studies which are still in progress it appears that *O. lamarckiana* and most of its mutants usually possess 14 somatic chromosomes; that *O gigas* has double that number, suggesting a variety like *Ascaris*

megalocephala bivalens; and that in the hybrids there may be an extraordinary disturbance in the number of chromosomes, the laws and the explanation for which are not apparent.

Methods and Publications.— Dr. R. M. Yerkes of Harvard University exhibited apparatus for testing color vision and the delicacy of visual discrimination in mice. Similar boxes are illuminated either by photometered lamps of different intensity or by colored lights. Over the floors of the boxes are wires for an interrupted electric current whereby the animal receives slight shocks when it enters the wrong box. The value of the apparatus is in its complete elimination of sensations other than those which are being tested. Under the title "The dancing mouse; a study in animal behavior," the MacMillan Company has in press a collected account of Dr. Yerkes' investigations of the mental life of a lower mammal.

Mrs. S. P. Gage of Ithaca, New York, showed her method of making models from sheets of blotting paper instead of plates of wax. The outline of the section is drawn upon the paper and may be cut out by the needle punctures from an unthreaded sewing machine. The blotting paper is then soaked in melted paraffin, and the smoothing of the surface, after the model has been put together, is done with paraffin. Pins are inserted, as in wax models, for stability. The resulting model is light and less fragile than those made of wax; it is not liable to change its shape in warm weather, or to crack by the expansion of metal supports.

Professor G. A. Drew of the University of Maine showed a method of making a series of anatomical drawings for reproduction by the zinc process. That part of the animal which is to appear in several drawings is drawn first, and photographed upon suitable paper. The figure is then completed by using pen and ink upon the photograph. Thus the organs may be drawn and photographed, and four figures of the nerves, arteries, veins, and lymphatics respectively may be built up upon this background. Professor Drew used the method in making his drawings of Pecten.

Dr. H. H. Field of Zürich exhibited a complete series of the card index to biological literature, issued by the Concilium Bibliographicum. It was shown properly arranged in a library cabinet, and its system was fully explained.

The Department of Comparative Anatomy at the Harvard Medical School exhibited a portion of its collection of 1188 series of vertebrate embryos, sectioned by the paraffin method. This collection may be used at the school by any visiting scientist.

The Secretary of the Universidad Nacional de Buenos Aires sent to the congress numerous photographs of its zoological gardens.

Professor W. B. Scott of Princeton University exhibited Vols. 1, 4, 5, and 8 of the Reports of the Princeton University Expeditions to Patagonia. These volumes, which are all that are now published, are devoted to the general narrative, botany, and paleontology. The entire work is expected to require fifteen volumes, and the expense of publication is met by the "J. P. Morgan Publication Fund." The narrative is said to compare in interest with Darwin's account of the voyage of the Beagle, and it may be printed in brief form for more general distribution.

Dr. H. Przibram of the University of Vienna showed copies of his *Einleitung in die experimentelle Morphologie der Tiere* published by F. Deuticke, Leipzig und Wien, 1904, and the *Experimental-Zoologie, 1, Embryogenese*, published by the same firm in 1907.

Dr. M. C. Piepers sent to the congress a copy of his book *Noch einmal, Mimicry, Selektion, Darwinismus*, published by E. J. Brill, Leiden, 1907. His earlier publication upon the same subject contained the theses which he presented to the Fifth International Zoological Congress, at Berlin, 1901.

Variation and Mendelism.— Professor W. Bateson of the University of Cambridge, England, whose address on "Facts limiting the theory of heredity" was of unusual interest, showed the great variation occurring in certain moths, and the results of cross-breeding in pigeons, poultry, and corn. Since this exhibit was not unpacked until the close of the congress, it could not receive the attention which it merited.

Professor T. Dwight of the Harvard Medical School invited the congress to inspect his very fine collection of variations in human bones, displayed in the Warren Museum.

Professor W. E. Castle of Harvard University exhibited live rabbits, guinea pigs, and rats, showing in a most effective way several forms of inheritance. The animals were exhibited in Cambridge, where breeding experiments are still being conducted on an extensive scale. The first series showed color varieties of the domesticated rabbit. The wild gray rabbit bears three independent heredity units,— one for black, one for yellow, and a third for barring (which causes the black and yellow to be disposed in bands upon the individual hairs). The various known color varieties result from the loss or modification of one or more of these three units. The inheritance is Mendelian. The unit composition of each known color variety was explained and in some cases demonstrated by the results of breeding experiments.

It was shown, for example, that in the absence of the barring factor, the black and yellow factors combine to produce three color varieties,—namely pure black, if the black factor is in excess; sooty yellow, if the yellow is in excess; and blue, if the black factor is modified and dilute and the yellow is scanty. Albino animals possess the color factors, but lack an activating substance necessary for pigmentation; the albino form may occur in any of the color varieties.

The second series showed color varieties of the guinea pig. As in the rabbit, the wild coat contains black, yellow, and barring factors which are inherited as independent units. There is also a separable brown factor which in the absence of the black and barring elements produces chocolate colored animals.

The third of the series exhibited was from a race of guinea pigs having four-toed hind feet. The hind feet of the guinea pig, agouti, and capybara are normally three-toed; those of rabbits are four-toed and of mice five-toed. By unremitting selection from the progeny of a single four-toed 'sport,' through five generations, a corresponding race of guinea pigs has become established. The effects of selection upon the color pattern (spots) of guinea pigs and rats were demonstrated, and the last series showed the blended inheritance of ear-length in rabbits. The offspring of a long-eared and a short-eared rabbit have ears of intermediate length, and breed true.

F. T. L.

ZOOLOGY

The Families and Genera of Bats.— One of the most important recent contributions to the taxonomy of the Chiroptera is "The Families and Genera of Bats," by Gerrit S. Miller, Jr., forming Bulletin 57 of the United States National Museum. It is a volume of about 300 pages, with 14 plates and 49 text cuts, illustrating the dentition, cranial and skeletal characters of this diversified order. The first 12 pages of the introduction are devoted to the technical history of the group, from Linnaeus (1758) to Weber (1904). This is followed by 30 pages on the anatomy of bats, relating especially to the structure of the wing, the shoulder girdle, and teeth, and by a systematic review of the genera and higher groups. The order Chiroptera is divided into the usually recognized two suborders, Megachiroptera and Microchiroptera, the former consisting of the single family Pteropidae,

or Fruit Bats, with 4 subfamilies and 30 genera; the latter containing all the others, which are here distributed among 16 families and 13 subfamilies.

This important monograph is based on the material contained in the U. S. National Museum and other American museums, supplemented by the examination of that contained in the principal museums of Europe, with the result that all but three of the 173 genera here recognized have passed through the hands of the author. The number of "forms" of Chiroptera at present recognized is stated to be about 900; "a number probably representing considerably less than half of what will eventually be known." The designation "forms" probably includes subspecies as well as species.

The systematic part (pp. 43–261) gives the characters of all the higher groups, from order to genus, with the geographic distribution and probable number of forms of each, and diagnostic keys for the suborders, families, subfamilies and genera. The divisions adopted, from families down to genera, are greatly in excess of those recognized by any previous author, but they appear to be all natural groups, subject of course to a different valuation by different authors, according to their points of view. No subgenera are recognized; of the 173 genera characterized, 19 have been proposed by Mr. Miller, only two of which, however, are here first published. For each of the genera a type species is designated, the probable number of species is stated, and those examined by the author are enumerated. The full synonymy is given, not only of the genera but of all the higher groups — a feature of much importance.

In this monograph, the outcome of years of careful investigation, Mr. Miller's usual thoroughness and critical attention to minute details of structure are conspicuously apparent, with the result that naturalists are now provided with an excellent guide through the labyrinths of this large and difficult order of mammals. The text cuts and the first ten plates furnish excellent illustrations, all original, of the dentition and cranial characters of about one third of the genera, thus supplementing in a most important way those contained in previous works, to which, however, direct references are unfortunately wanting. The last four plates illustrate the principal parts of the skeleton in four diverse types — *Rhinopoma microphyllum, Diclidurus virgo, Noctilio leporinus, Molossus pretiosus.*

J. A. A.

Birds of North and Middle America.— Mr. Robert Ridgway's "Birds of North and Middle America" is the most important syste-

matic work ever undertaken relating to American ornithology. The original estimate for the work was a series of eight volumes, in octavo, of about 1000 pages each. Its official designation is "Bulletin of the United States National Museum, No. 50." The first volume appeared near the close of the year 1901, and included the single family Fringillidae; the second was published in 1902, and covers the four families Tanagridae, Icteridae, Coerebidae, and Mniotiltidae; the third bears date 1904, and includes 15 of the remaining families of oscinine Passeres; the fourth, published in July of the present year, includes the remaining six families of the Oscines and the first four families of the Mesomyodi. These families are: Turdidae, Zeledoniidae, Mimidae, Sturnidae, Ploceidae, Alaudidae of the Oscines; Oxyruncidae, Tyrannidae, Pipridae, Cotingidae, of the Mesomyodi. These four volumes include "1675 species and subspecies, or somewhat more than half the total number of North and Middle American birds," or those found north of the Isthmus of Panama, which forms approximately the southern boundary of the area treated. The preparation of Part V is well advanced.

The treatment is entirely technical; definitions are given of all the higher groups, with keys to the minor divisions, and in the case of genera to the species and subspecies. The latter are described in detail, with a concise statement of their geographic ranges, followed by full (often annotated) bibliographic tables, which often frequently occupy the larger part of the text. But there is nothing relating to their life histories beyond, in some instance, a brief reference under the generic headings to the nest and eggs. The work is, however, invaluable to the systematist, and will ever remain a monument to the industry and painstaking accuracy of its author, and it will be long before its usefulness will be superceded by any subsequent work.

J. A. A.

BOTANY

Floral Ecology.— In the writings of Darwin and his contemporaries the structure and environmental relations of flowers hold a prominent place. This is only natural when we remember that the Darwinian theory is essentially a theory of adaptation. For a considerable time it seemed that interest in floral adaptations was lagging, but this kind of work is again being quite generally taken up. Possibly a reason for

the renewal of interest is to be seen in the completion of Knuth's Handbuch, and certainly the popularity of this kind of investigation is attested by the promise of a complete translation of this large work from the Oxford press.

It is not surprising that the Italians, who until very recently have had Delpino — a pioneer in this field — among them, should show especial activity in studies of floral ecology. The Orto Botanico della R. Università di Napoli is now commencing the republication (Bull. Orto Bot. R. Univ. Napoli 2:3–65. 1904) of a portion of Delpino's Ulteriori Osservazioni which first appeared in 1873–'74. This is unquestionably one of the most important treatises on floral ecology and its republication will be welcomed by many to whom the original is not accessible. Delpino's elaborate classification was proposed at a time when there was not a broad basis of observation but the conception is certainly worthy of the most careful consideration and one of the chief problems before future workers in this field is to determine in how far floral adaptations may be thrown into real categories such as Delpino suggests. This is to be one of the crucial tests of adaptation which we need at the present stage of development of the evolution theory.

Before passing from the work of Delpino, it may not be out of place to mention that an appreciation of the man and a bibliography of his writings has just been published by Briosi (Atti Ist. Bot. Univ. Pavia II. 10: vi–xxi. 1907). Over one hundred and twenty titles are given, a large proportion of them being on various phases of vegetable ecology.

The fifth memoir of Scotti's series on the floral biology of the "Personatae" may be mentioned as another large undertaking. This number (Annali di Botanici 5: 101–227. 1907) comprises the families Solanaceae, Scrophulariaceae, Bignoniaceae, Martyniaceae, Pedaliaceae, Orobanchaceae, Gesneriaceae, Lentibulariaceae, Globulariaceae and Acanthaceae. The work is largely a review of the literature on the floral ecology of these groups but it serves a useful purpose in bringing together in one place a detailed discussion of a large body of widely scattered observations.

Mattei (Bull. Orto Bot. R. Univ. Napoli 2:115–117. 1904) gives lists of visitors of *Dracunculus vulgaris*. Nicotra (Bull. Soc. Bot. Ital. 1906:128–131) discusses the floral ecology of Urginea, Agave and Smilax. Graenicher has published two papers (Bull. Nat. Hist. Soc. Wisc. n. s. 5:15–45, 84–95. 1907) on the pollination of Wisconsin flowers. In these the families Melanthaceae, Liliaceae, Convallariaceae, Saxifragaceae, and Grossulariaceae are considered. The obser-

vations are very similar to those made by Müller and MacLeod in Europe and by Robertson in our own country and it is to be hoped that the author will continue the work with vigor.

Burck has been engaged in studies of anther dehiscence and concludes (Proc. Kon. Akad. Amsterdam 1906: 390–396, and Rev. Gén. Bot. 19: 104–111. 1905) that the opening of the anther is effected by the withdrawal of water from the anther by sugar contained in the filament. This permits the dehiscence of the anther in an atmosphere saturated with moisture.

Harms (Ber. Deutch. Bot. Ges. 25: 165–176. 1907) has investigated cleistogamy in three species of the genus Clitoria. The studies were made on herbarium material. The author concludes that we are here dealing with a real cleistogamy in the sense in which Göbel uses the term. The characteristics of the cleistogamous flowers are the small size of the calyx, the absence of the corolla and a more or less pronounced reduction in the androccium.

Tuzson (Bot. Jahrb. 40: 1–14. 1907) has observed cleistogamy in *Robinia pseudacacia*. Two trees were found together in the same row of old trees along a street and he thinks it probable that one was derived from the other by vegetative reproduction. The individuals were about thirty to forty years old and have been under observation since 1902; since then they have flowered in 1904 and 1906. Fertilization occurs exceedingly rarely. In these forms cleistogamy must be considered a highly disadvantageous characteristic which originated discontinuously and which would be eliminated in the struggle for existence. The author does not agree with all of Göbel's views on cleistogamy but insists on the causal rather than the teleological attitude in the investigation of the problem.

Dop (Bull. Soc. Bot. Fr. IV. 7: 258–260. 1907) again discusses the mechanism of movement in the stamens of the Berberidaceae.

Fritsch (Verh. K. K. Zool.-Bot. Ges. Wien 56: 135–160. 1906) publishes list of insect visitors for about 150 species of the flora of Steiermark. The observations were made in 1904.

J. Arthur Harris.

PUBLICATIONS RECEIVED

From August 1 to September 1, regular exchanges are not included
The year of publication, when not otherwise noted is 1907

HOUGH, T., AND SEDGWICK, W. T. *Elements of Physiology.* Boston, Ginn & Co., 1907. 12mo, 321 pp., illus. $1.25.— NEWMAN, H. *Laboratory Exercises in Elementary Physics.* Boston, Ginn & Co., 1907. In four parts. **$1.50 per dozen.**

ALLEN, W. F. Distribution of the subcutaneous vessels in the head region of the Ganoids, Polyodon and Lepisosteus. *Proc. Washington Acad. Sci.*, vol. 9, pp. 79–158, pls. 1–15.— COOK, O. F. Mendelism and other methods of descent. *Proc. Washington Acad. Sci.*, vol. 9, pp. 189–240.— COOK, O. F. Origin and evolution of angiosperms through apospory. *Proc. Washington Acad. Sci.*, vol. 9, pp. 159–178.— DALL, W. H. Linnaeus as a zoologist. *Proc. Washington Acad. Sci.*, vol. 9, pp. 272–274.— DAVENPORT, C. B. Heredity and Mendel's law. *Proc. Washington Acad. Sci.*, vol. 9, pp. 179–188.— FELT, E. P. White marked tussock moth and elm leaf beetle. *N. Y. State Mus.*, bull. 109, 31 pp., 8 pls.— GREENE, E. L. Linnaean memorial address. *Proc. Washington Acad. Sci.*, vol. 9, pp. 241–271.— MANN, A. Report on the diatoms of the Albatross voyages in the Pacific Ocean, 1888–1904. *Cont. U. S. Nat. Herbarium*, vol. 9, pt. 5, pp. 221–442, pls. 44–54.— MC BAIN, J. W. The experimental data of the quantitative measurements of electrolytic migration. *Proc. Washington Acad. Sci.*, vol. 9, pp. 1–78.— MEEK, S. E. Synopsis of the fishes of the Great Lakes of Nicaragua. *Field Columbian Mus.*, zool. ser., vol. 7, no. 4, pp. 97–132.— MERRILL, G. P. Catalogue of the type and figured specimens of fossils, minerals, rocks, and ores. *Bull. U. S. Nat. Mus.*, no. 53, pt. 2, 370 pp.— MILLER, G. S. The families and genera of bats. *U. S. Nat. Mus.*, bull. 57, 282 pp., 14 pls.— RIDGWAY, R. The birds of North and Middle America, part IV. *Bull. U. S. Nat. Mus.*, no. 50, 973 pp., 34 pls.— STEJNEGER, L. Herpetology of Japan and adjacent territory. *U. S. Nat. Mus.*, bull. 58, 577 pp., 35 pls., 409 figs.— WHEELER, H. J. AND ADAMS, G. E. Continued test of nine different phosphates upon limed and unlimed land with several varieties of plants. *R. I. Agric. Exp. Sta.*, bull. 118, pp. 55–86.— WHEELER, H. J., HARTWELL, B. L., MORGAN, J. F., AND PURRINGTON, W. F. Analyses of commercial feeding-stuffs. *R. I. Agric. Exp. Sta.*, bull. 119, pp. 89–107.

ANNALS OF THE QUEENSLAND MUSEUM, no. 7.— NEW YORK STATE MUSEUM. REPORT ON INJURIOUS AND OTHER INSECTS.— PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES FOR 1907, part I.— ABSTRACT OF PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES, June 26th, 1907.

(No. 489 was issued Sept. 26, 1907).

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

EDITED BY

WILLIAM K. BROOKS
WILLIAM E. CASTLE
EDWIN G. CONKLIN
CHARLES B. DAVENPORT
HERBERT S. JENNINGS
FRANK R. LILLIE
JACQUES LOEB
THOMAS H. MORGAN
GEORGE H. PARKER
CHARLES O. WHITMAN
EDMUND B. WILSON

ROSS G. HARRISON, Managing Editor

CONTENTS OF VOLUME IV

NO. 1, FEBRUARY, 1907

Abnormal Development of Toad Ova Fertilized by Spermatozoa Exposed to the Roentgen Rays . . . . Charles R. Bardeen
An Ecological and Experimental Study of Sarcophagdae with Relation to Lake Debris . . . . . William B. Herms
Rejuvenescence as the Result of Conjugation . . . . Sara White Cull
Artificial Parthenogenesis in Thalmessema Mellita . . . George Lefevre
Concerning the Theory of Tropisms . . . . . Jacques Loeb
The Mechanism of the Galvanotropic Orientation in Volvox Frank W. Bancroft

NO. 2, MAY, 1907

The Influence of External Factors, Chemical and Physical, on the Development of Fundulus Heteroclitus . . . Charles R. Stockard
The Energy of Segmentation . . . . . Edward G. Spaulding
Movement and Problem Solving in Ophuria Brevispina . . Otto C. Glaser
The Occurrence of a Sport in Lina Lappomica and its Behavior in Heredity . . . . . Isabel McCracken
Experiments in Transplanting Limbs and Their Bearing upon the Problems of the Development of Nerves . . . . Ross G. Harrison
Factors in the Regeneration of a Compound Hydroid, Eudendrium ramosum . . . . . A. J. Goldfarb

PRICE OF SUBSCRIPTION PER VOLUME

(PAYABLE IN ADVANCE)

To subscribers in the United States, Canada and Mexico	$5.00
To subscribers in other countries	5.50
Price of single copies	2.00

These prices are under no consideration subject to discount

Remittances should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to the Journal of Experimental Zoology

ADDRESS ALL COMMUNICATIONS TO

THE JOURNAL OF EXPERIMENTAL ZOOLOGY

N. E. Cor. Wolfe and Monument Streets

BALTIMORE, MD., U. S. A.

The first of a series of Colored Plates of the

THRUSHES

OF

NORTH AMERICA

By FUERTES & HORSFALL,

was published in BIRD-LORE for February.

The series will be concluded this year

---

20 CENTS A COPY. $1.00 A YEAR

THE MACMILLAN CO.

NEW YORK CITY

THE AMERICAN JOURNAL OF SCIENCE

Established by BENJAMIN SILLIMAN in 1818

The Leading Scientific Journal in the United States

Devoted to the Physical and Natural Sciences, with special reference to Physics and Chemistry on the one hand, and to Geology and Mineralogy on the other.

Editor: EDWARD S. DANA

Associate Editors: PROFESSOR GEORGE L. GOODALE, JOHN TROWBRIDGE, W. G. FARLOW, and WM. M. DAVIS, of Cambridge; PROFESSORS A. E. VERRILL, HENRY S. WILLIAMS, and L. V. PIRSSON, of New Haven; PROFESSOR G. F. BARKER, of Philadelphia; PROFESSOR JOSEPH S. AMES, of Baltimore; MR. J. S. DILLER, of Washington.

Two volumes annually, in **monthly numbers** of about 80 pages.

This Journal ended its *first* series of 50 volumes as a quarterly in 1845; its *second* series of 50 volumes as a two-monthly in 1870; its *third* series as a monthly ended December, 1895. A FOURTH SERIES commenced in January, 1896.

Subscription price $6.00 per year or 50 cents a number, postage prepaid in the United States; $6.40 to foreign subscribers of countries in the Postal Union. A few sets on sale of the *first*, *second*, and *third* series at reduced prices. *Ten-volume index numbers* on hand **for the second and third series.**

THE AMERICAN JOURNAL OF SCIENCE

NEW HAVEN, CONN.

FOR BIRD STUDENTS AND BIRD LOVERS EVERYWHERE.

THE CONDOR

A BI-MONTHLY MAGAZINE OF WESTERN ORNITHOLOGY

EDITED BY J. GRINNELL.

OFFERS IN VOLUME 9

In MAKE-UP, the highest grade in paper, typography and illustration and every detail that counts.

In ILLUSTRATION, the best work of Messrs. Finley and Bohlman, work that is unsurpassed in any field.

In SUBJECT MATTER, the results of recent studies by active workers in the western field; interest and scientific value, the standard.

SUBSCRIPTION, $1.50 PER YEAR. SAMPLE COPY, 30 CENTS

H. T. CLIFTON, BUSINESS MANAGER, P. O. BOX 404, PASADENA, CAL.

ALONE IN ITS FIELD

THE LIVING AGE

is the only American Magazine exclusively devoted to the reprinting, without abridgment, of the most important and interesting articles from the best English periodicals.

Published weekly, it is able to present this material while the topics considered are still fresh in the public mind.

With the whole range of English periodical literature to select from, it is able to present more important articles by well-known and brilliant writers than any other single magazine. It publishes

The Best Fiction **The Best Essays**

The Best Literary Criticism

The Best Travel Articles

The Ablest Discussions of Public Affairs

The single numbers are light and easy to hold, and the reading matter is not smothered in advertising. The numbers for a year contain as much as two of the four-dollar magazines.

The LIVING AGE has been published every Saturday without missing an issue for more than 63 years, and was never more indispensable than now to intelligent readers.

New subscribers for 1908 will receive free the remaining numbers of 1907 from the date on which their subscriptions reach the publishers. Specimen copy free.

Terms: $6.00 a year

Three Months' Trial Subscription, $1.00

THE LIVING AGE COMPANY

6 Beacon Street, Boston, Mass.

VOL. XLI, NO. 491 NOVEMBER, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	Response of Toads to Sound Stimuli	S. A. COURTIS	677
II.	Further Notes on the Behavior of Gonionemus	MAX MORSE	683
III.	Pleistocene Plants from Alabama	EDWARD W. BERRY	689
IV.	A Further Study of Leaf Development	FREDERIC T. LEWIS	701
V.	Earthworms as Planters of Trees	E. A. ANDREWS	711
VI.	The Cause of Gynandromorphism in Insects	T. H. MORGAN	715
VII.	Notes and Literature: *General Biology*; Mental development in the child and the race.—Racial descent in animals.—Hough and Sedgwick's Physiology. *Zoology;* The nervous system of vertebrates.—The sense of touch.—The young of the red kangaroo.—A note of the prairie-dog owl.—Feathered game of the northeast.—Game laws for 1907.—Notes on the structure of insects.—Notes		719
VIII.	Publications Received		731

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

The American Naturalist

EDITOR

FREDERIC T. LEWIS, M. D., *Harvard Medical School, Boston, Mass.*

ASSOCIATE EDITORS

J. A. ALLEN, PH.D., *American Museum of Natural History, New York.*
E. A. ANDREWS, PH.D., *Johns Hopkins University, Baltimore*
WILLIAM S. BAYLEY, PH.D., *Colby University, Waterville*
DOUGLAS H. CAMPBELL, PH.D., *Stanford University*
J. H. COMSTOCK, S.B., *Cornell University, Ithaca*
WILLIAM M. DAVIS, M.E., *Harvard University, Cambridge*
ALËS HRDLICKA, M.D., *U. S. National Museum, Washington*
D. S. JORDAN, LL.D., *Stanford University*
CHARLES A. KOFOID, PH.D., *University of California, Berkeley.*
J. G. NEEDHAM, PH.D., *Cornell University, Ithaca*
ARNOLD E. ORTMANN, PH.D., *Carnegie Museum, Pittsburg*
D. P. PENHALLOW, D.SC., F.R.S.C., *McGill University, Montreal*
H. M. RICHARDS, S.D., *Columbia University, New York*
W. E. RITTER, PH.D., *University of California, Berkeley*
ERWIN F. SMITH, S.D., *U. S. Department of Agriculture, Washington.*
LEONHARD STEJNEGER, LL.D., *Smithsonian Institution, Washington*
W. TRELEASE, S.D., *Missouri Botanical Garden, St. Louis*
HENRY B. WARD, PH.D., *University of Nebraska, Lincoln*
WILLIAM M. WHEELER, PH.D., *American Museum of Natural History New York*

THE AMERICAN NATURALIST is an illustrated monthly magazine of Natural History, and will aim to present to its readers the leading facts and discoveries in General Biology. Anthropology, Zoology, Botany, Paleontology, and the several branches of Geology.

The contents each month will consist of leading original articles containing accounts and discussions of new discoveries, reports of scientific expeditions, biographical notices of distinguished naturalists, or critical summaries of progress in some line; in addition to these there will be briefer articles on various points of interest, editorial comments on scientific questions of the day, and critical reviews of recent literature.

All naturalists who have anything interesting to say are requested to send their contributions; candidates for the higher scientific degrees are invited to contribute concise summaries of the special literature pertaining to their chosen topics. The editors will endeavor to select for publication only that which is of true scientific value and at the same time so written as to be intelligible, instructive, and interesting to the general scientific reader.

All manuscripts. books for review, exchanges, etc., should be sent to FREDERIC T. LEWIS, M. D., Harvard Medical School, Boston, Mass.

All business communications should be sent to MESSRS. GINN & COMPANY, 29 Beacon St., Boston, Mass.

Annual subscription, $4.00, net, in advance. Single copies, 35 cents
Foreign subscription, $4.60

GINN & COMPANY, PUBLISHERS

THE

AMERICAN NATURALIST

VOL. XLI *November, 1907* No. 491

RESPONSE OF TOADS TO SOUND STIMULI

S. A. COURTIS

THE sense of hearing in frogs has been critically studied by Dr. R. M. Yerkes. He tested the effect of a great variety of sounds upon frogs in their natural habitat and states that "To no sound have I ever seen a motor response given."[1] The sounds ranged in pitch from a low tone in imitation of the bull frog's croak to a shrill whistle, and in loudness from the fall of a pebble to the report of a pistol. He says further,—"One can approach to within a few feet of a green frog or bull frog and make all sorts of noises without causing it to give any signs of uneasiness. Just as soon, however, as a quick movement is made by the observer the animal jumps. I have repeatedly crept up very close to frogs keeping myself screened from them by bushes or trees and made various sounds, but have never succeeded in scaring an animal into a motor response so long as I was invisible. Apparently they depend almost entirely upon vision for the avoidance of dangers...Many observers have told me that frogs could hear the human voice and that slight sounds made by a passer-by would cause them to stop croaking. In no case, however, have such observers been able to assert that the animals were unaffected by visual stimuli at the same time.... There is, however, conclusive evidence that the animals hear one another, and the probability is very great that they hear a wide range of sounds to which they give no motor reactions."

In a later study,[2] Dr. Yerkes found experimentally that although

[1] Yerkes, R. M. The instincts, habits and reactions of the frog. *Harvard Psychological Studies*, 1903, vol. 1, pp. 629–630.

[2] Yerkes, R. M. The sense of hearing in frogs. *Journ. of Comp. Neur.*, 1905, vol. 15, pp. 279–304.

frogs gave no motor reaction to various sounds, their response to tactile stimuli accompanied by these sounds was greater than to the tactile stimuli alone. He concludes that sounds varying in pitch from those of 50 to 10,000 vibrations affect the frog. In nature, "the sense of hearing apparently serves rather as a warning sense which modifies reactions to other simultaneous or succeeding stimuli than as a control for definite auditory motor reactions." In the spring months he found that sounds had a marked influence upon both males and females, but during the winter there was "a much diminished sensitiveness to auditory stimuli in both sexes, but especially in the male."

The description of Dr. Yerkes' experiments given by Professor Kirkpatrick, at Chicago University, greatly interested the writer. Having once kept a frog through the winter and often succeeded in making him croak by imitating his call, it seemed probable that motor responses followed certain sounds. On July 1st I had an opportunity of testing the response of toads to the mating call.

In the course of a walk along the shore of Lake Michigan, we came to a shallow pool in the sand just behind a breakwater. The pool was three or four inches deep, six or eight feet wide, and several hundred feet long. In one part of this we found nine pairs of toads, the females laying eggs in long strings upon the bottom of the pool. There were also two or three unpaired males. The males were much smaller than the females and much more active. The females were of great size, their sides being puffed out with eggs. On the sand they were too heavy to hop, and so walked on all fours like a dog. One female had been seized by two males. We separated her from both, and placed them about ten feet apart. One of the males soon uttered a shrill, trilling note,— a penetrating sound that was well sustained for fifteen or twenty seconds. In doing so he puffed out the skin of his under jaw into a dark gray translucent hemisphere of large size, as is the well known habit of toads. The female immediately swam towards him and the two were soon mated.

After this preliminary experiment we made three others. In the first we separated four couples, putting the females on a little island in the middle of the pool and the males into the water about ten feet away. In four or five minutes they were all mated in

response to the calls from the males. The second time, we separated all the couples in sight, nine I think, and placed the females as before, the males a little farther away. The third time, we separated them all, but put the males on the island where the females had been and carried the females at least thirty feet away towards the side where the males had been. In fifteen minutes, in both cases, every female was taken. In the last case one that had at first hopped ten feet in the wrong direction turned completely around in her tracks at the call, and at the next call, started towards the male.

There were many interesting things observed during the experiments. For one thing the males as well as the females responded to the call, which they could locate very accurately. At the beginning of an experiment, as soon as the males were put down they began to scatter in all directions, swimming excitedly about, now this way, now that. When there were twelve unattached males within four or five feet, a call by one of their number would bring the others from all directions, and in a second or two there would be one or two heaps of clasping, fighting, kicking males, squealing like mice, and rolling over and over. Not all the males gave the call — not over four or five individuals — and these were, as far as I could judge, the most sluggish among them. In giving the call there was quite a marked tendency to climb out of the water up on to a scantling on the inner side of the breakwater. The toads were then two inches above the water.

Motion was evidently the stimulus that started the clasping reflex. This was clearly shown on the sand where I saw one male overtake, clasp, and release another male four or five times in succession before the second succeeded in escaping. Each time the motion of the toad in front would start the one behind. A male would release a male almost instantly, but I did not see a single case of a female clasped and released. How they knew the female I could not tell, but they evidently did not recognize one until they had clasped her. The clasping action, as already stated, seemed entirely automatic.

Several of the solitary males that were sounding the call watched the approach of the females, cocking their heads on one side and moving their bodies so as to look down, and if the swimming

impulse of the female had stopped so that she was carried to the male by her inertia, he would make no response until she began again to swim. Provided that the female is motionless a male may remain for several minutes almost touching her, even in the water, without apparently being aware of her presence. I saw the same thing several times in males and females accidentally thrown together during the fighting. In some cases the female, in responding to a call, would swim right by a male approaching from the side, so that neither seemed to recognize the other.

The females are able to locate the exact spot from which a call is issued. In most cases, at the first or second call, they turned so as to face in the general direction from which it came, the effect being most noticeable with eight or nine females on the sand together. Before the call they faced in all directions,— after the call in one, the most sensitive animals moving two or three feet toward the call at once. The effect was much like that of bringing a strong magnet near a lot of small compass needles. At the next, or some succeeding call, a start would be made, the toads swimming vigorously for a few seconds, then floating forward on the surface of the water until their motion was spent. Often when a female started not more than eight or ten feet away from the calling male, its nose would hit the scantling on the inner side of the breakwater just underneath where the male was sitting. I feel sure, though, that this was not because it saw the male. In one case the calling male faced so that he could not see the approach of the female just beneath him. An inch or two at one side was a mated couple. The female, on reaching the spot where the male was, would be attracted by the motions of the couple and swim towards them, only to leave them immediately and swim across the pool to the other side. This was repeated several times in succession. As already stated, when a female had started towards a calling male, she would pay no attention to any males coming towards her from the side. This was so marked that the response appeared purely mechanical.

One peculiar thing I noticed, or fancied I noticed — for it was hard to be sure — was that the response of a toad, either male or female, was much more rapid and vigorous when in a crowd of its kind than by itself. The first five or six females were mated

within as many minutes, but these may have been the more sensitive toads as I had no means of distinguishing one from another.

From these observations I conclude that both male and female toads can hear and locate in space the call of the male; that the response is unintelligent and mechanical; that to the sound of the mating call a motor response is given, which serves to bring the sexes to the same place; that motion is the stimulus which starts the clasping reflex; that neither sex is able to recognize the other without actual contact; that toads do not quickly profit by experience.

In comparing the single set of observations here recorded with the experiments of Dr. Yerkes, it will be noted that toads were employed in the former and frogs in the latter; it is not probable, however, that there is any considerable difference in the acoustic sense of such closely related animals. It will also be noted that the observations were made in the early summer, when, according to Dr. Yerkes, the sensitiveness to sound is at its best. But even so, the response observed was greater than the results obtained by Dr. Yerkes seem to indicate. It is possible that the frog is capable of hearing and responding to the call of its mate but has no response ready for the report of a pistol or the Galton whistle. It would be interesting to make a phonographic record of the male call, try its effect on females, and observe the result of changing its pitch, quality, and character. The call of the male is not a continuous but a throbbing sound. Nerves that are just beginning to be sensitive to sound might well need a slower rate of vibration than that of the sound itself, and this the throbbing would supply. It was easily perceptible to the ear, so I suppose could not have been at the rate of more than fifteen or twenty vibrations to a second. In Dr. Yerkes' experiments the throbbing electric bell produced "the most marked modification of reaction, probably because it consists, like the induced electric shock, of a rapid succession of stimulating changes." He states that "the green frog is stimulated by sounds as low as 50 vibrations per second; no experimental tests were made with lower sounds."

It is possible that the failure in the laboratory to obtain motor reactions to sound was due to the character of the sound or to other features of experimentation; on the other hand my observa-

tions are concerned with a motor response to only one sound, at one season. The toad reacts directly to the vibrations of the mating call transmitted thirty or forty feet through the air.

DETROIT HOME AND DAY SCHOOL
Detroit, Michigan

FURTHER NOTES ON THE BEHAVIOR OF GONIONEMUS

MAX MORSE

The following notes upon the response of this jelly-fish, Gonionemus, to light supplement those published by the writer in the *Journal of Comparative Neurology and Psychology* in 1906 (Vol. 16, p. 450–456). All the experiments to be described were made in a dark-room to which sunlight was admitted by means of a porte-lumière apparatus. The aquarium was 100 cm. long, 70 cm., wide and 50 cm. deep.

That light has a directly orienting effect on the animal is seen from the following experiment. The light was admitted through the slit, Fig. 1, *a*, and was reflected vertically downward upon the medusa, *b*, as it lay upon the bottom of the aquarium. The light fell upon one side of the medusa only, so that unilateral stimulation was produced. The cylinder of light was 5 cm. in diameter and therefore sufficient to cover one half of the body and the tentacles belonging thereto, even when extended. Owing to the difficulty of determining definitely the reaction when the medusa lay with its apex downward, it was in each case turned over. After one half of the bell had been illuminated for from 5 seconds to three minutes, the reaction occurred. The first movement carried the medusa vertically upward and it was only after it had pulsated three or four times that its path veered from the perpendicular. It might turn towards the light (Fig. 1, *bc*) or away from it (*bd*) or be so indefinite as not to be placed in either of these categories. The results of one hundred trials, upon different individuals in the main, are appended; those marked "indefinite" are the responses where the animal had not moved far enough to become oriented before ceasing to pulsate: —

Towards the light . . .	9 reactions.
Away from the light . . .	70 reactions.
Indefinite	21 reactions.

The effect of unilateral stimulation on a swimming jelly-fish

was tried. Care was taken to have the impinging ray as nearly as possible parallel to the oral-aboral axis of the animal. When thus illuminated, the medusa changed its course, moving away from the axis of light so that the path formed an acute angle with the ray.

Attention was then directed to the movements of Gonionemus when swimming freely in an aquarium illuminated from one direction. Figure 2 explains the arrangement. The sunlight was reflected through the aquarium from side to side (xy). A jelly-fish was freed at the point a, and it at once sank to the bottom. Within a few seconds it began to swim and finally reached the top of the water. The path, however, was not vertical, but was inclined away from the light as shown by the path Ab. On reaching the surface, the ordinary reaction took place whereby it inverted and sank in the vertical line bB. The process was repeated so that the resultant of the whole was the direction Ah. In this way it will be seen that the medusa ultimately reaches the farthermost point, as a result of the light acting exactly as in the simpler experiments in unilateral stimulation. In one case, that of a strong swimmer, the path followed was not broken by frequent inversions, inasmuch as the animal did not reach the surface until it had passed to the opposite side of the aquarium, a distance of about 70 cm.

That it is the direction of the ray of light that is the important factor in orientation, is made evident by the following experiment (Fig. 3). It will be seen that the light was thrown upon the aquarium at the angle indicated by the arrow, so that the end abc, lying nearer the source of light, is dark, the opposite end being illuminated. When a medusa starts at b in the light, it rises to the top and performs the actions just described, so that it reaches ultimately the end d. By this means we find an accumulation of jelly-fish in the end farthest from the light. Here they will remain until they die, or, as is often the case, they begin to swim regardless of the direction of the light and ultimately reach the shaded area, in which they settle down as described in my previous paper.

Yerkes [1] has described a very interesting response in Gonionemus

[1] Yerkes, R. M. Concerning the Behavior of Gonionemus. *Journ. Comp. Neur.*, 1906, vol. 16, p. 457–463.

under unilateral stimulation, a reaction observed many times by the writer. The animal is seen to pull the bell out of the light by means of its tentacles. Careful observation shows that the tentacles within the lighted area are not attached, but lie extended and passive. The bell itself is likewise motionless. The case is different with the portion of the bell and its tentacles lying in the shade, as these parts are generally more or less active. It is very improbable that there is any complex coordination here that

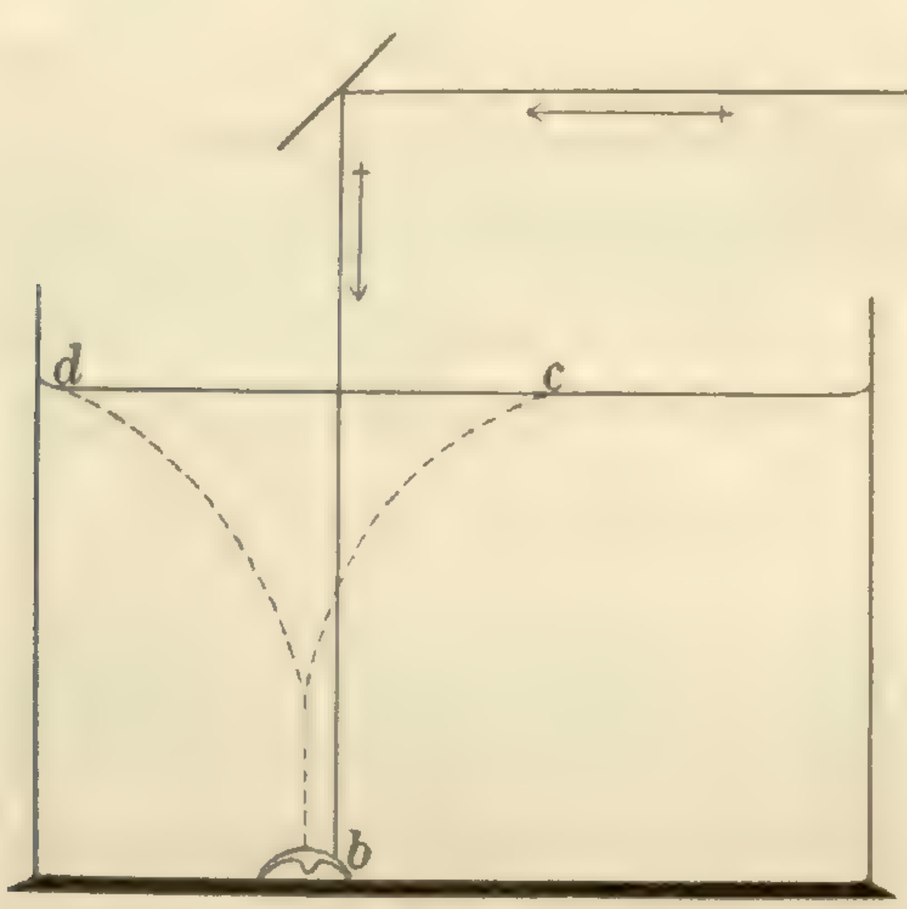


Fig. 1

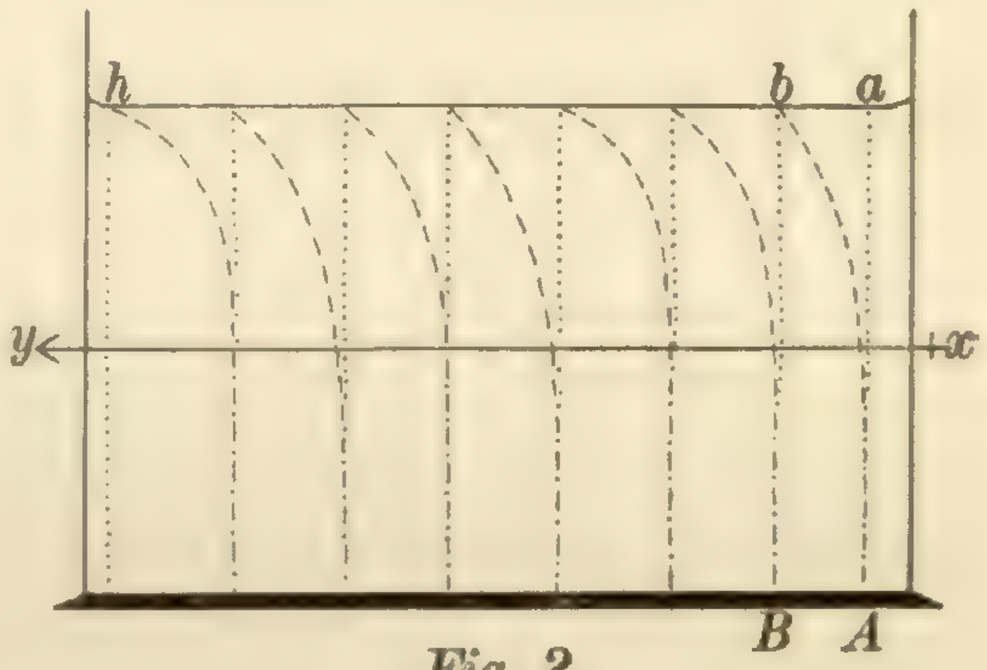


Fig. 2

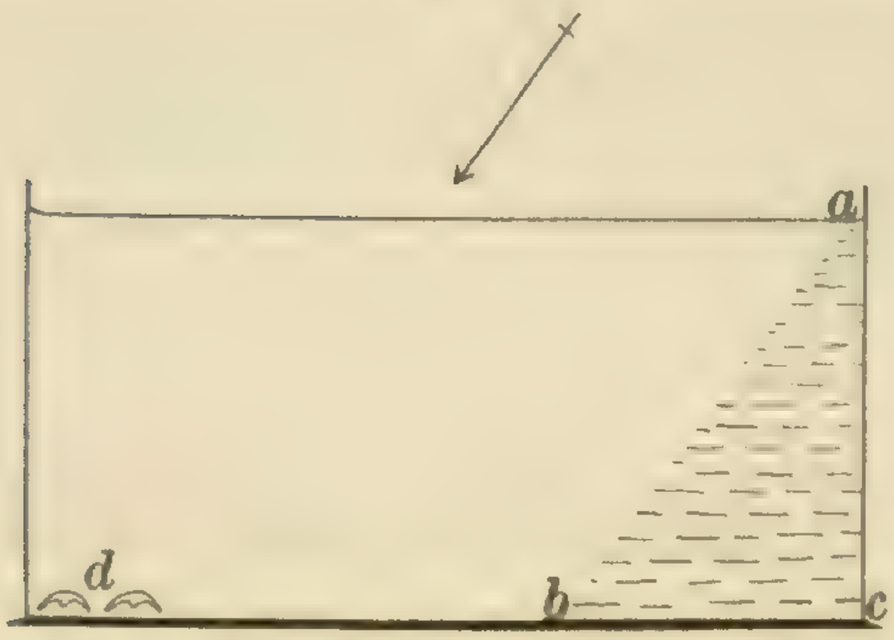


Fig. 3

Fig. 4

Figs. 1–4.—Diagrams illustrating the response of Gonionemus to light.

serves to move the body away from an area of light. The action seems to be wholly undirected. This interpretation is strengthened by the fact that, in some cases, the body has been drawn directly into the sunlight by those tentacles belonging to the illuminated side, the tentacles themselves being shaded. At other times the tentacles of one side of the body were seen to be carried up over the bell and to become attached to the underlying sand on the opposite side of the jelly-fish, after which the animal turned a

complete somersault by means of the tentacles. At first this was observed in medusae resting in the sunlight; the action was likewise seen in animals in the shade so that it has nothing whatsoever to do with the effect of light.

In the notes previously published, the writer made an attempt to determine the cause of the peculiar behavior of the animal in inverting the bell on reaching the surface of the water. The medusa has no mechanism other than contact whereby it can turn the bell on a transverse axis and thus invert it; it is never observed to turn in its path abruptly. As the equilibrium of the bell is destroyed when the animal reaches the surface and pushes one edge of the bell through the surface film, the inversion occurs. It frequently happens that medusae are found that will not remain mouth down even when so placed by hand. Such individuals kept from inverting pulsate violently for long intervals and come to rest only when they are turned over.

In the paper just cited, the writer interpreted the accumulation of Gonionemus in the shade as the result of trial and error. Further work has strengthened this conclusion. Only in the special case where the shadow will be met as the medusa moves away from the source of light, can this be *directly* the result of the orienting factor of light. This is shown in the experiment illustrated by Fig. 4, a view of the aquarium from above. The light is sent lengthwise through the aquarium and parallel with its base. One side is shaded. Individuals freed at *A* in the sunlight, move in their characteristic way to the farther end of the aquarium. Some, moving irregularly, enter the shaded area and remain there. Ultimately, the great majority of the animals are found in this area as described in the previous paper.

Yerkes[1] has described the light reactions of this medusa in the following words,—

> "Gonionemus always settles down in a shaded region,—in other words, it is negatively photokinetic or photopathic.
>
> When a number of the medusae are placed in a glass vessel before a window they usually collect in the darkest region of the vessel. A simple test of this was made by putting a number of the animals in a dish having a bottom

[1] Yerkes, R. M. A Contribution to the Physiology of the Nervous System of the Medusa *Gonionemus murbachii*. Part I. *Amer. Journ.* Phys., 1902, vol. 6, p. 446.

16 × 10 inches and a depth of 3½ inches, one-half of which was covered with a black cloth. By way of illustration, the results of one test were as follows: eight animals were put into the dish in the afternoon at four o'clock; within fifteen minutes all were in the light half of the vessel, and there they remained with some changes of position until nine o'clock in the evening. At seven o'clock the next morning only one was in the light region, and of the others several were attached to the sides and bottom of the dark region of the dish. Similar results were gotten with several lots.

Again, when Gonionemi in a glass collecting pail are disturbed by agitation of the water, they swim about rapidly and in a few minutes most of them are found on the more intensely illuminated side of the vessel. If, now, they are allowed to remain undisturbed for an hour, they will be found either equally distributed throughout the vessel or collected in the darker region.

There are here two questions to be answered. First, why do the animals at first come to the light? Secondly, why is it that they are later found in the shaded regions? The following statement of the relation of the motor reaction of Gonionemus to stimulation by light accounts for the facts. In ordinary daylight they are, *when swimming*, positively phototactic; in very weak light, on the contrary, they are not directed by the stimulus to any considerable degree, and therefore appear to be indifferent. They come to rest in an intensity of light which is below that necessary to direct their movements to any important extent and are therefore negatively photopathic."

In a later paper[2] he described, as follows, a new set of experiments which corroborate his earlier conclusions.

"Eleven medusæ were placed in a white earthenware dish. The dish was illuminated by direct sunlight. After a few seconds, one-half of the dish was covered with a piece of black card-board. Within a minute ten of the eleven medusæ were in the sunlit portion of the dish and there they remained for about two and one-half minutes, swimming about actively but without moving far in any direction. Then as quickly as they had gathered in the sunlit portion they moved to the shaded portion and in less than a minute, all but two were in the shade of the cardboard."

In my former paper (p. 452) I stated that, by the use of a large jar, "33 cm. high and 21 cm. in diameter," no such reaction was observed. I can only add that the experiments conducted during the past summer with the aquarium 100 cm. by 70 cm. by 50 cm. bear out this conclusion. The collecting of the medusae in the light does not occur where large vessels are used and where reflections from the sides are eliminated. The writer believes that Yerkes' results were modified by the use of a small vessel with

[2] Yerkes, R. M. Concerning the Behavior of Gonionemus. *Journ. Comp. Neur.*, 1906, vol. 16, p. 459.

highly reflecting sides. Moreover, it is not clear from Yerkes' text that light of the same intensity was used since some of his experiments were conducted from 4 in the afternoon until 9 at night; at such times the light would be constantly decreasing in intensity. Again, he obtained the reaction by agitating the water, setting the medusae swimming in all directions. Under such conditions it would be very difficult to determine how much the movements of the jelly-fish were due to its own activities and how much to the currents set up by the agitation.

The writer's experiment described above where light was thrown on a swimming medusa shows too, that the reaction to light is the same in an individual swimming as in one at rest, and not different, as Yerkes believes. Inasmuch as experiments conducted under more normal and more carefully arranged conditions do not exhibit the reaction, the writer believes that Gonionemus is *at no time* positively phototactic.

These experiments lead, moreover, to the conclusion that the reaction of Gonionemus to light is a tropic one, and that the accumulation of the animals in shaded areas is referable to the method of "trial and error."

The thanks of the writer are due to Dr. T. H. Morgan for many suggestions in regard to the work and to the Marine Biological Laboratory for facilities.

COLLEGE OF THE CITY OF NEW YORK

PLEISTOCENE PLANTS FROM ALABAMA[1]

EDWARD W. BERRY

In the course of the cooperative study of the Atlantic coastal plain from the Potomac river southward during the past season, plant-bearing beds of Pleistocene age have been discovered at various localities, more particularly in Virginia, North Carolina and Alabama. A rather interesting and highly fossiliferous deposit of this character occurs along the Chattahoochee river in Russell County, Alabama, where the collections upon which the following brief communication is based were made by Dr. L. W. Stephenson of the Federal Survey, who also very kindly furnished the sections here given. The locality is a few hundred yards below Abercrombies Landing on the Alabama side of the Chattahoochee river, and about seven and one-half miles below Columbus, Georgia.

The recognizable leaf-remains have been found at two levels: they occur in an upper layer of hard, dark drab, rather pure clay which dries to an ash color, and in a lower layer of very dark impure peat. The leaf-remains found in the clay are fairly permanent, but those in the peat are very perishable and have been saved and identified by allowing the material to become thoroughly macerated in water and then carefully floating out the larger fragments; from these, sun-prints giving the exact outline are made before the specimens become thoroughly dry. If allowed to become too dry they crumble to powder. After the prints have been made the specimens are mounted on small cards and coated with glue, but even in this condition they are extremely fragile and liable to destruction.

The following two diagrammatical sections were taken about 100 yards apart; No. 1 shows the leaf-bearing horizons, the lower of which is partially concealed by land slips, and No. 2 shows a complete section to the water's edge. From the way in which the base of the exposure is concealed in section No. 1, it is impossible

[1] Published by permission of the Director of the U. S. Geological Survey.

to be certain that the peat is in place in the section and does not represent more recent drift material; however, the opinion of the collector and all of the circumstantial evidence are strongly in favor of the view that it is a true Pleistocene deposit, somewhat older than the overlying beds. The argument for this interpretation may be briefly stated as follows:—The peat which was uncovered over an area two by ten feet had every appearance of forming an integral part of the section. The material itself is very similar to the somewhat more argillaceous material occurring at the same level, and in place, in section No. 2. Seven species have been detected both in the peat and in the overlying clay, the latter unquestionably Pleistocene. These forms are *Quercus virginiana* Mill, *Quercus prinus* Linné, *Quercus nigra* Linné, *Betula nigra* Linné, *Platanus occidentalis* Linné, *Carpinus caroliniana* Walt., and *Ulmus alata* Michx.

The deposits record progressive changes in the conditions of deposition which may be recast somewhat as follows:—The lower gravel bed probably represents material deposited near the mouth of a stream with considerable current, during the brief erosion interval immediately preceding the deposition of the peat. With the subsequent subsidence of the land the lower stream valleys were transformed into estuaries and a barrier beach was built by wave action, which impounded the stream or lagoon, forming a swamp where the peaty material was accumulated. With the continued sinking of the land the advancing shore line spread a mantle of gravel (the upper gravel bed) over the swamp and with the still greater depression of the region, the overlying clays were deposited in quiet estuary waters.

With regard to the exact stage of Pleistocene represented, it is very probable that these Chattahoochee materials are to be correlated with those late Pleistocene beds which have been called the Talbot formation in Maryland and Virginia, and which contain numerous similar swamp deposits. The species of plants represented are all forms which occur in the recent flora of Alabama, although the present range of some of them is considerably different. For example, the northern limit of the live oak is about one hundred miles due south while the southern limit of the chestnut oak is about forty miles due north of Abercrombies Landing.

The willow oak is also rare as far south as this point although it is abundant a few miles to the northward.

The flora as a whole furnishes no evidence of climatic conditions appreciably different from those which exist at the present time in this region, although the grouping of species was quite different from that which obtains along the present Gulf coast.

The presence of *Tsuga canadensis* (Linné) Carr., and *Betula*

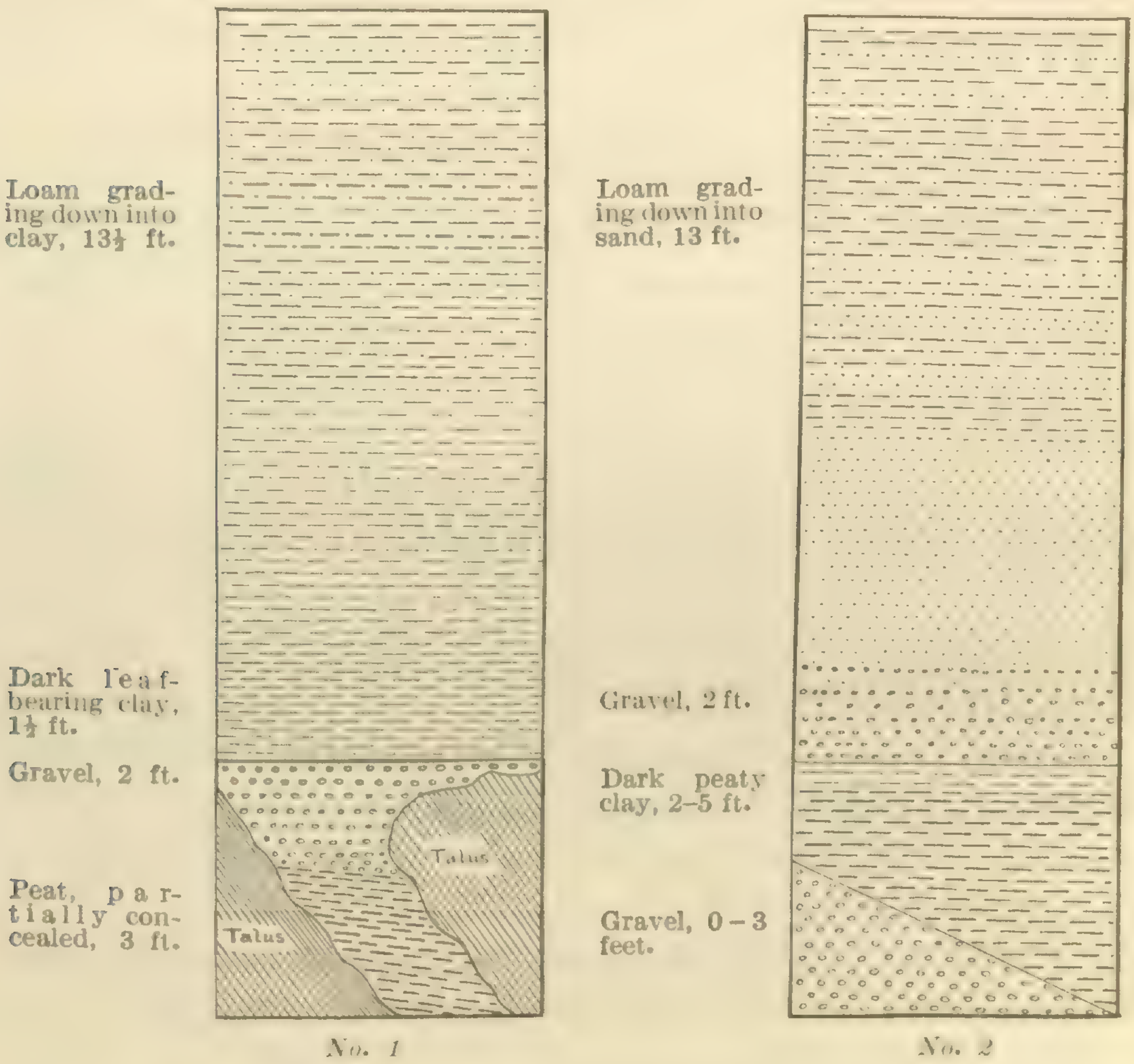


FIG. 1. Pleistocene sections along the Chattahoochee river in Alabama. *No. 1* is about three hundred feet north of *No. 2*.

lenta Linné in the existing flora of Alabama at an isolated locality in Winston county, miles south of their usual range, coupled with the presence of the larch in the Pleistocene of Georgia, would seem to indicate cooler conditions at some time in the Pleistocene, presumably at an earlier time than is represented by the fossils from near Abercrombies Landing.

In addition to the species enumerated below, there are a con-

siderable variety of small seeds, husks of Hicoria, and the cone scales and needles of Pinus, which it has seemed best not to determine positively at the present time. Remains of the cypress (Taxodium) and the gum (Nyssa) which are usually present in deposits of this age have not been detected.

FAGALES

Carpinus caroliniana Walt., *Fl. Car.*, p. 236, 1788.
Pl. 1, Figs. 8, 9.

Berry, *Journ. Geol.*, vol. 15, p. 340, 1907.

A species of low rich woods which ranges from Canada to Florida and Texas and is common throughout Alabama. The fossil leaves are present in both the peat and the overlying clays. Recently recorded by the writer from the Pleistocene of North Carolina.

Betula nigra Linné, *Sp. Pl.*, p. 982, 1753.
Pl. 2, Figs. 2–4.

Knowlton, *Amer. Geol.*, vol. 18, p. 371, 1896.
Berry, *Journ. Geol.*, vol. 15, p. 341, 1907.

A species which in the modern flora ranges from New England to Texas and which is common throughout Alabama, especially along the stream banks. Several leaves occur in both the peat and the clays and a small fragment of the characteristic bark was also detected in the peat. This species has been previously recorded from the Pleistocene of North Carolina and West Virginia.

Fagus americana Sweet, *Hort. Brit.*, p. 370, 1826.
Pl. 2, Fig. 7.

Berry, *Torreya*, vol. 6, p. 88, 1906; *Journ. Geol.*, vol. 15, p. 341, 1907.
Hollick, Maryland Geological Survey, *Pliocene and Pleistocene*, p. 226, 1906.

Fagus ferruginea Michx., Lesquereux, *Amer. Journ. Sci.*, vol. 27, p. 363, 1859; *Geol. of Tenn.*, p. 427, pl. 7 (K), fig. 11, 1869.

Fagus ferruginea Ait., Knowlton, *Amer. Geol.*, vol. 18, p. 371, 1896.

Mercer, *Journ. Phila. Acad.*, (ii), vol. 11, pp. 277, 281, fig. 8 (15), 1899.

In the modern flora the beech is a prominent element in the mesophile valley forests of the Alleghenian, Carolinian and Louisianian zones. It was also a very prominent Pleistocene type and has been recorded from the Pleistocene of Pennsylvania, Maryland, Virginia, West Virginia, North Carolina and Tennessee. Near Abercrombies Landing it is represented in the peat by four or five of the characteristic husks, two nuts and one imperfect leaf.

Quercus nigra Linné, *Sp. Pl.*, p. 995, 1753.
Pl. 1, Figs. 3, 4.

Berry, *Journ. Geol.*, vol. 15, p. 342, 1907.

This species ranges in the Recent from the Louisianian zone northward as far as Delaware and is common throughout Alabama where it inhabits low rich woods and sandy pine-barren swamps. It is by far the most abundant leaf in the peat deposits, possibly due to its ability to resist decay; in the clays a single impression was found, showing the basal two thirds of a leaf. This species has recently been recorded by the writer from the Pleistocene of North Carolina.

Quercus virginiana Mill, *Gard. Dict.*, Ed. 8, No. 16, 1768.
Pl. 1, Fig. 2.

The live oak is a tree of the sea-coast, and in Alabama rarely occurs north of latitude 31°. Thus its northern limit in this state is about one hundred miles due south of Abercrombies Landing,—collateral evidence, if such were necessary, that the Pleistocene sea or estuaries of it reached as far north as this point in the late Pleistocene. The species is present in both the peat and in the overlying clays, and so far as I am aware has not previously been recorded in the fossil state.

Quercus prinus Linné, *Sp. Pl.*, p. 996, 1753.
Pl. 1, Fig. 5.

Berry, *Journ. Geol.*, vol. 15, p. 342, 1907.

The chestnut oak is a tree of the rocky woods and hillsides and makes its best growth in Alabama on elevations exceeding eight hundred feet. Its present southern limit coincides approximately with the isothermal line of 60° F., which also serves to mark the boundary between the Carolinian and the Louisianian zones. This line crosses the Chattahoochee river near West Point, Ga., or about forty miles due north of Abercrombies Landing. Two leaves were found in the peat, and one fragmentary specimen showing venation but not marginal characters is from the overlying clays. It was recently recorded by the writer from the Pleistocene of North Carolina where it is present in considerable abundance.

Quercus phellos Linné, *Sp. Pl.*, p. 994, 1753.
Pl. 1, Fig. 1.

Berry, *Journ. Geol.*, vol. 15, p. 342, 1907.

The willow oak is a common element in the mesophile forests of the northern part of Alabama; it becomes rare, however, south of the long-leaf pine belt which stretches across the central part of the state, its southern boundary crossing the Chattahoochee river just north of Abercrombies Landing. The fossil leaves are a common element in the peat but have not been detected in the overlying clays. It was recently recorded by the writer from the Pleistocene of North Carolina where it is very common.

Ulmus alata Michx., *Fl. Am. Bor.*, vol. 1, p. 173, 1803.
Pl. 1, Figs. 6, 7.

Berry, *Journ. Geol.*, vol. 15, p. 343, 1907.

The water elm is common throughout Alabama and ranges northward as far as southern Illinois and Virginia. The Pleistocene material from Abercrombies Landing contained two fragmentary specimens, one from the peat and the other from the overlying clays. These leaves show the characteristic serrated margin of this genus. They are smaller and narrower than the leaves of *Ulmus pseudo-racemosa* Hollick from the Pleistocene of Maryland and the character of the marginal teeth is also somewhat different. The state of preservation indicates that the surface was roughened or somewhat pubescent in life. They are identical with the more perfect leaves which I have referred to this species from

the Pleistocene of North Carolina, and also agree admirably with leaves from the existing tree, so that the identification is reasonably sure in spite of the meager materials.

Ranales.

Liriodendron tulipifera Linné, *Sp. Pl.*, p. 535, 1753.

The tulip tree is a common mesophile type of the Alleghenian, Carolinian and Louisianian zones, its southern limit in Alabama being about latitude 31°. Material from Abercrombies Landing contained two positively identified winged carpels and several more doubtfully determined fragments all of which came from the peat. The genus Liriodendron, which has such an extremely interesting geological history,[1] has furnished a large number of American Cretaceous species ranging from the mid-Cretaceous onward, but none have been found in the American Tertiary. In Europe and the Arctic regions, however, a number of Tertiary forms have been described, especially from the Pliocene,— the leaves of *Liriodendron procaccinii* Unger from France and Italy being scarcely distinguishable from those of the existing species. The material from Alabama is, so far as I am aware, the first Pleistocene record of Liriodendron, although Schmalhausen records leaves which he has identified as this species from the Altai Mountains of Central Asia in strata which he refers doubtfully to the Pliocene.[2]

Rosales.

Platanus occidentalis Linné, *Sp. Pl.*, p. 999, 1753.

Pl. 2, Fig. 5.

Knowlton, *Amer. Geol.*, vol. 18, p. 371, 1896.

Penhallow, *Trans. Roy. Soc. Can.*, (ii), vol. 2, sec. 4, pp. 68, 72, 1896; *Amer. Nat.*, vol. 41, p. 448, 1907.

Mercer, *Journ. Phila. Acad.*, (ii), vol. 11, p. 277, 1899.

Berry, *Journ. Geol.*, vol. 15, p. 344, 1907.

[1] Berry, Notes on the Phylogeny of Liriodendron, *Bot. Gaz.*, vol. 34, pp. 44–63, 1902.

[2] Schmalhausen, Ueber tert. Pflanzen aus dem Thale des Flusses Buchtormia am Fusse des Altaigebirges. *Palaeontographica*, vol. 33, 1887.

Platanus aceroides Göpp., Hollick, Maryland Geological Survey, *Pliocene and Pleistocene*, p. 231, pl. 73, 74, 1906.

In the modern flora this species inhabits low woods and banks from Canada to Florida and Texas. In Alabama it frequents the bottom lands of the central part of the state and is infrequent in the southern part. It is an abundant Pleistocene type and has been previously recorded from Canada, Pennsylvania, Maryland, West Virginia and North Carolina. The Abercrombies Landing remains include the fragment of a central part of a leaf shown in the figure, which has the characteristic venation but none of the marginal characters and which comes from the clays; and a still smaller fragment from the underlying peat which shows one of the marginal points.

SAPINDALES.

Ilex opaca Ait., *Hort. Kew.*, vol. 1, p. 169, 1789.
Pl. 2, Fig. 1.

Hollick, *Bull. Torrey Club*, vol. 19, p. 331, 1892.
Berry, *Journ. Geol.*, vol. 15, p. 345, 1907.

The holly frequents damp banks and hammock lands in Alabama and ranges northward to New York and southeastern Massachusetts. It has been recorded by Hollick from the supposed Miocene at Bridgeton, N. J., and by the writer from the North Carolina Pleistocene. A single specimen was found at Abercrombies Landing in the peat.

ERICALES.

Xolisma ligustrina (Linné) Britton, *Mem. Torrey Club*, vol. 4, p. 135, 1894. Pl. 2, Fig. 6.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene*, p. 236, pl. 69, fig. 6, 1906.
Berry, *Journ. Geol.*, vol. 15, p. 346, 1907.

In the present Alabama flora the typical forms of this species inhabit the damp banks of small streams in the mountainous portion of the state. It is of a generally more northern distribution, having its southern limit along the southern edge of the metamor-

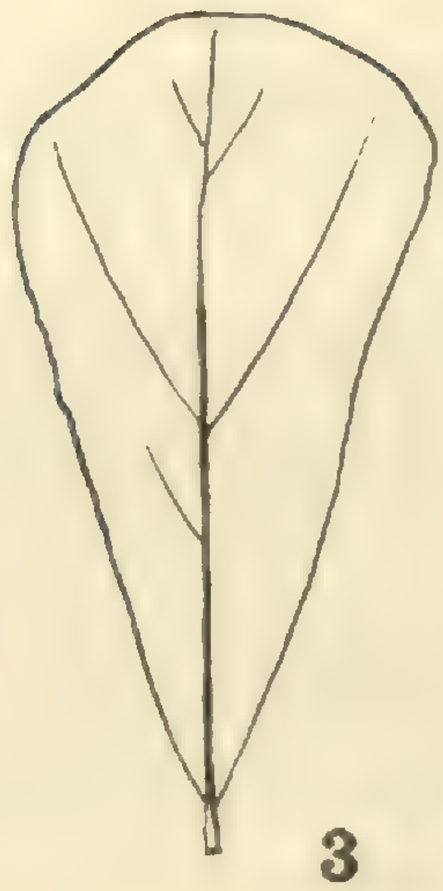
phic hills in Lee county, and is not a member of the Louisianian flora. In a fossil state it has been previously recorded from Maryland and North Carolina. At Abercrombies Landing it is confined to the peat. *Xolisma foliosiflora* (Michx.) Small which Mohr[1] considers to be only a variety of this species, and which is common in the Alabama coastal plain and on lowlands westward into Louisiana and northward as far as Virginia, is apt to have leathery leaves which are usually distinctly serrulate. It may be considered to be the coastal plain descendant of the more ancient *Xolisma ligustrina*.

JOHNS HOPKINS UNIVERSITY
Baltimore, Md.

[1] Mohr, *Bull. Torrey Club*, vol. 24, p. 24, 1897.

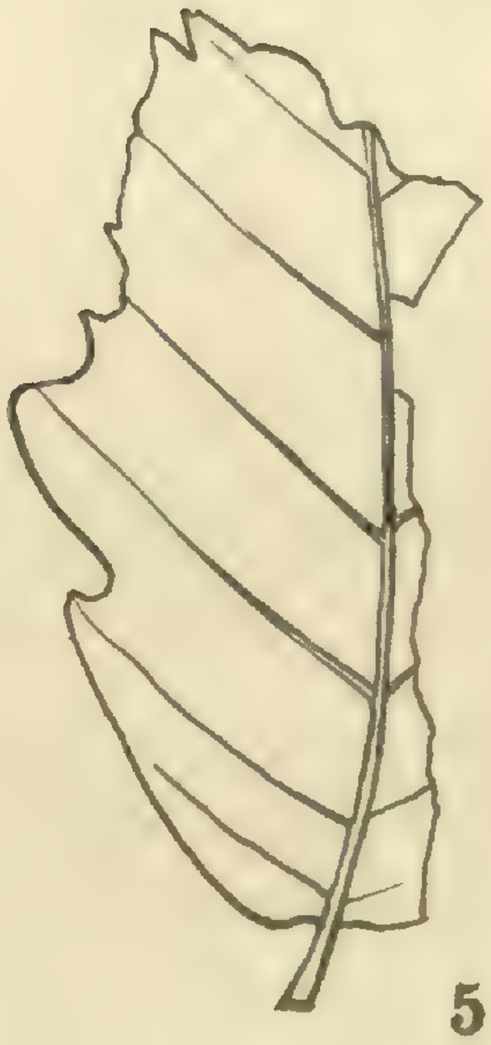
1

2

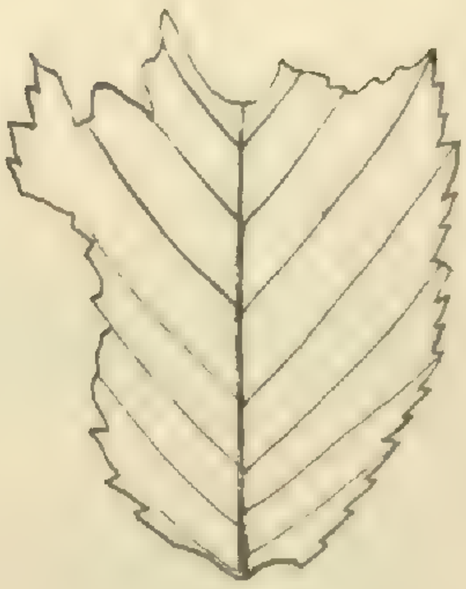


3

4



5



6

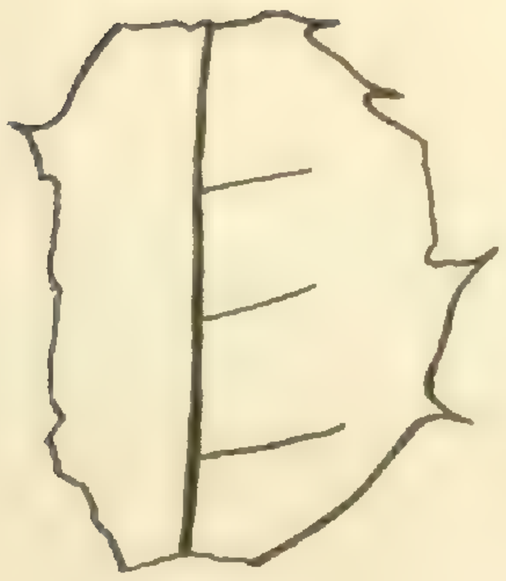
7

8

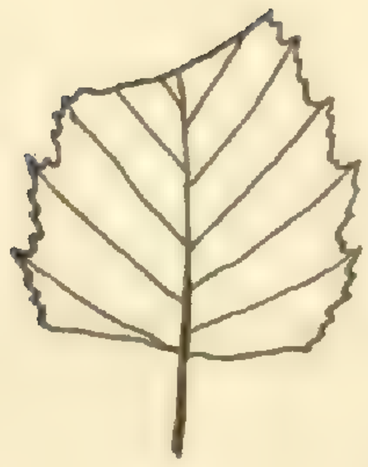
9

PLATE I

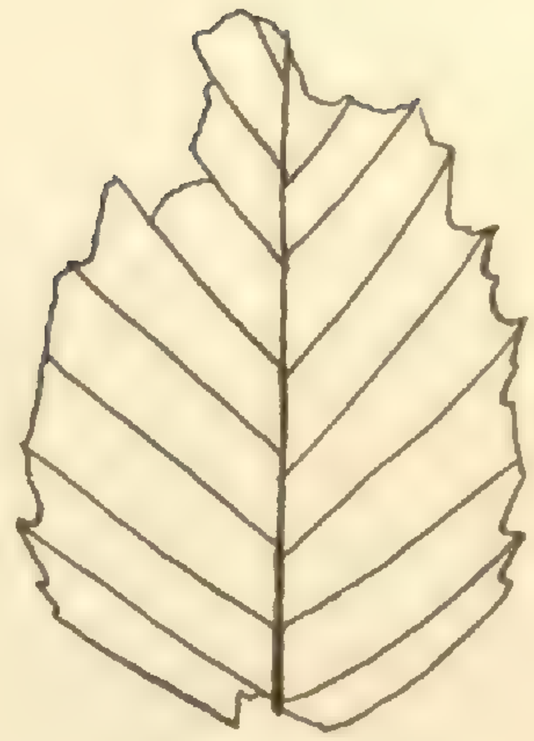
Fig. 1.—*Quercus phellos* Linné . . peat.
Fig. 2.—*Quercus virginiana* Mill . clay.
Figs. 3, 4.—*Quercus nigra* Linné . peat.
Fig. 5.—*Quercus prinus* Linné . . peat.
Fig. 6.—*Ulmus alata* Michx. . . peat.
Fig. 7.—*Ulmus alata* Michx. . . clay.
Fig. 8.—*Carpinus caroliniana* Walt. peat.
Fig. 9.—*Carpinus caroliniana* Walt. clay.



1



2



3

4

5

6

7

PLATE 2

Fig. 1.—*Ilex opaca* Ait . . . . peat.
Figs. 2, 3.—*Betula nigra* Linné . . clay.
Fig. 4.—*Betula nigra* Linné . . . peat.
Fig. 5.—*Platanus occidentalis* Linné peat.
Fig. 6.—*Xolisma ligustrina* (Linné) Britton . . . . . peat.
Fig. 7.—*Fagus americana* Sweet . peat.

A FURTHER STUDY OF LEAF DEVELOPMENT

FREDERIC T. LEWIS

In a previous paper (*Amer. Nat.*, 1907, vol. 41, p. 431–441) the writer discussed whether certain forms of adult leaves could be regarded as due to arrested development, so that by comparing the mature leaves of a given plant something of their embryological history could be learned. It was found that where leaflets are formed embryologically from the base toward the apex, as in most pinnate leaves, the terminal leaflet of the mature leaf is often lobed. Where leaflets are formed from the apex toward the base, as in most palmate leaves, the basal leaflets are often lobed. In the rose, in which the leaflets are also formed from the apex toward the base, neither apical nor basal leaflets are lobed, but new leaflets appear near the stipules to which they are often joined. In the previous paper the sumac and honey locust were described as basifugal forms, and the blackberry and rose as basipetal, the latter being of the stipular type. In the following pages it will be shown that the basipetal and basifugal directions of growth may both occur in a single leaf; and that, although one becomes predominant, evidences of the other are apparent. In some cases a single species presents both pinnate and palmate leaves.

The simplest form of compound leaf is three-parted or ternate, and is produced by the lateral lobation of a simple leaf. The stages in this process as seen in the mature leaves of *Clematis virginiana* are shown in Figs. 1a–1d. A ternate leaf may be basipetal in character and pass on to digitate forms with four, five, or more leaflets, or it may be basifugal and produce pinnate leaves. The leaf of Clematis, Fig. 1d, exhibits both tendencies. Basipetal growth is manifest in the coarser teeth on the lower margins of the lateral leaflets and in the fact that the part of each lateral leaflet below the midrib is wider than the part above. Basifugal growth is shown in the coarse tooth on either side of the apical leaflet. Although *Clematis virginiana* stops ordinarily at this

stage, the "very similar" western *Clematis ligusticifolia* goes further, and, by the deepening of the notches in the terminal leaflet, becomes pinnate with five leaflets. Many other species of Clematis, including some which are commonly cultivated, have pinnate leaves.

In the poison ivy, *Rhus toxicodendron*, simple leaves are occasionally found, but the typical form is ternate. Many leaves exhibit both basipetal and basifugal features (Fig. 2a), and explain the occurrence of both palmate and pinnate leaves in this species (Figs. 2b and 2c).

An interesting comparison may be made between the leaves of the black raspberry, *Rubus occidentalis*, and the wild red raspberry, *Rubus strigosus*. In the former, Figs. 3a and 3b, the basipetal tendency predominates, leading to pedate leaves; a basifugal notching of the terminal leaflet is, however, often observed. In the closely related red raspberry basifugal growth leads to pinnate leaves, Figs. 4a and 4b, but basipetal lobation may be seen in the basal leaflets.

The form of leaf shown in Figs. 1d, 2a, 3a, and 4a is seen also in Fig. 5a from *Negundo aceroides*. In the pinnate leaves of this species there may be a basal secondary leaflet, as shown in Fig. 5b. Such evidence of basipetal growth in pinnate leaves is often found. It appears in the long leaves of *Ailanthus glandulosus* (Fig. 6b). In the seedling of this species, ternate leaves with basal notches have been drawn by Jackson,[1] from whose paper Fig. 6a has been taken. Thus it is evident that the basipetal and basifugal directions of growth are present together in a great variety of leaves.

The relation of the basipetal secondary leaflets to twice pinnate leaves is shown in Figs. 7, 8, and 9. In the elder, *Sambucus canadensis*, the basifugal development of primary leaflets is shown in Fig. 7a.[2] The basipetal formation of secondary leaflets appears

[1] Jackson, R. T. Localized stages in development in plants and animals. *Mem. Boston Soc. Nat. Hist.*, 1899, vol. 5, pp. 89–153.

[2] Goebel (*Organographie der Pflanzen*, Jena, 1900, pt. 2, vol. 2, p. 525) classes *Sambucus ebulus* with the basipetal leaves and *Sambucus nigra* with the basifugal. He states,— "Since in nearly related plants the order of development of pinnate leaflets is sometimes basifugal and sometimes basipetal, not much importance can be attached to this distinction."

FIGS. 1a–1d, mature leaves of *Clematis virginiana* L. 2a–2d, *Rhus toxicodendron* L. 3a–3b, *Rubus occidentalis* L. 4a–4b, *Rubus strigosus* Michx. 5a–5b, *Negundo aceroides* Moench.— ¼ natural size, except 1a, 1b, 1c, and 2b which are ⅔.

in Fig. 7b. If the process of compounding proceeds further, a smaller secondary leaflet will be cut off opposite the one on the lower border of the primary leaflet (Fig. 7c). Thus the basal primary leaflet becomes pinnate and develops further in the basifugal manner. This order of leaflet formation is seen not only in the elder, but in *Aralia nudicaulis* (Figs. 8a–8c) and in *Cicuta maculata* (Figs. 9a–9b). It is of widespread occurrence.

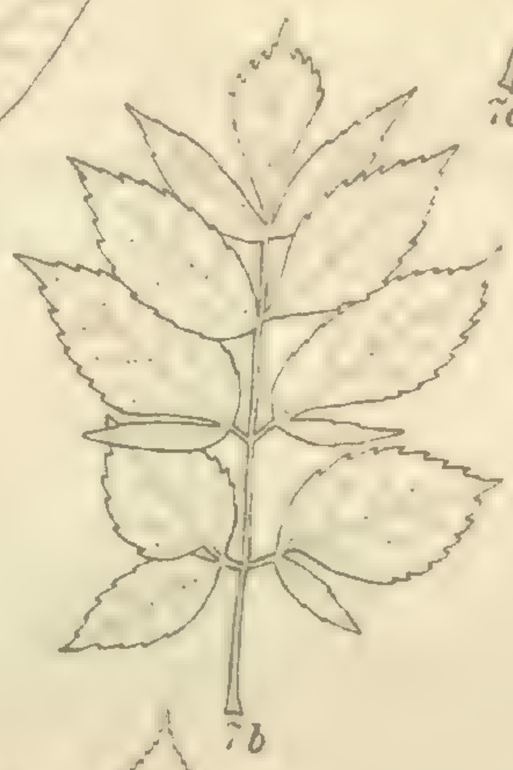
An unusual exception to the basal formation of secondary leaflets is seen in many leaves of *Bidens frondosa* (Fig. 10). In this species the secondary leaflets are usually on the upper margin of the basal leaflets. They may become matched by leaflets on the lower margin, and sometimes the leaflet on the lower side is formed first. Frequently in *Sambucus canadensis* the secondary leaflets first appear on the distal sides of the basal leaflets, as in Bidens, but usually they develop on the basal side, both in Sambucus and in most of the species examined.

The development of the pinnate leaves of the rose, as described in the previous paper, is so different from that of other pinnate leaves as to require further study. Eichler[1] has classed with the rose, as basipetal in development, the leaves of *Sanguisorba officinalis*, *Poterium sanguisorba*, *Potentilla anserina*, and "probably all potentillas with compound and divided leaves." The basipetal nature of the palmate leaves of *Potentilla canadensis* is obvious. In "Gray's Manual" they are described as "ternate but apparently quinate by the parting of the lateral leaflets." Frequently they develop seven leaflets without lobation of the central leaflet. In *Potentilla fruticosa*, however, the central leaflet shows various degrees of indentation, and if one may judge from mature leaves, basifugal growth occurs. The entire leaf is pinnate. *Potentilla anserina* also shows lobed terminal leaflets.[2] It is possible in these forms that the proximal leaves are added basipetally but they are not connected with the stipules, and lobed proximal leaflets were not observed in the plants examined.

The same is true of agrimony leaves. Basal lobation and fusion with stipules were not observed. Terminal lobation (Fig. 11) was shown in two leaves among four hundred and fifty.

[1] Eichler, A. W. Zur Entwickelungsgeschichte des Blattes. Marburg, 1861, 60 pp.

[2] Goebel agrees with Eichler in considering *Potentilla anserina* as basipetal.



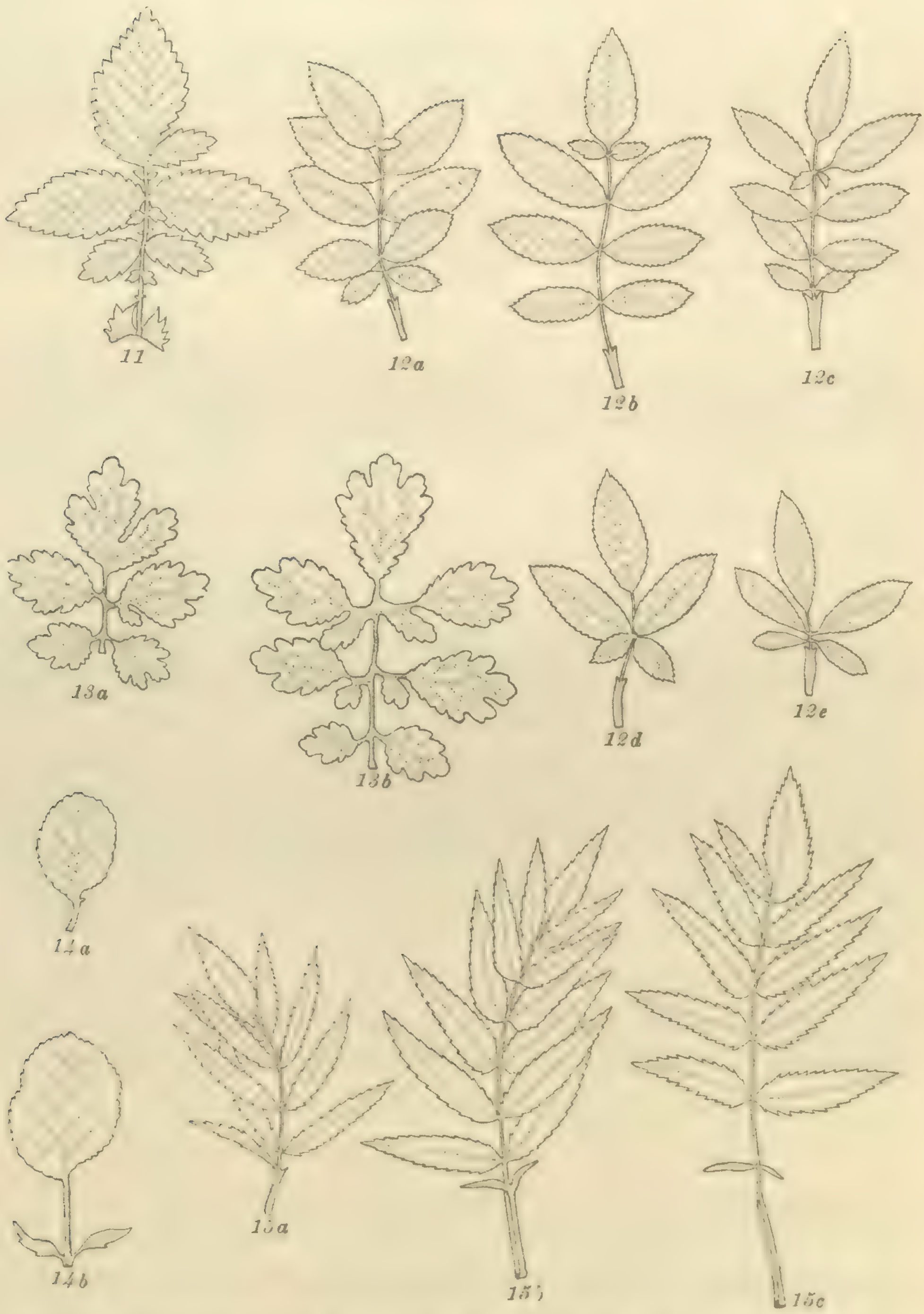
FIGS. 6a–6b, *Ailanthus glandulosus* Desf.; 6a, from a seedling, after Jackson; 6b, the distal and proximal parts of a mature leaf having 13 pairs of leaflets. 7a–7c, *Sambucus canadensis* L. 8a–8c, *Aralia nudicaulis* L. 9a–9b, *Cicuta maculata* L. 10, *Bidens frondosa* L.— 6a, × $\frac{5}{8}$; 6b, × $\frac{1}{8}$; 9a and 9b, × $\frac{1}{3}$; the others, × $\frac{1}{4}$.

Twenty-seven hundred leaves of *Rosa lucida* yielded none with a lobed terminal leaflet, but basifugal growth was suggested by the two leaves figured as 12a and 12b. Several leaves with secondary leaflets attached to the distal pair of primary leaflets were observed (Fig. 12c). In Sambucus, Aralia, and Cicuta, the oldest leaflets are the ones which give rise to secondary leaflets, and they are consequently found toward the base of the leaf. Their distal position in the rose may be correlated with basipetal development. In the celandine, however, in which growth seems clearly basifugal, the distal leaflets produce secondary leaflets as in the rose (Figs. 13a and 13b).

Among the twenty-seven hundred rose leaves there were none with the proximal leaflets lobed. One pedate leaf was found (Fig. 12d) together with several forms like that in Fig. 12e. These suggest that leaflets cut off from the basal pair may be carried down the petiole as should occur in a truly basipetal pinnate leaf. However, lobation of the proximal leaflets of a ternate leaf leading to the production of a pinnate leaf has never been found by the writer, and the rose leaves in Figs. 12d and 12e may be explained by the close approximation of the two basal pairs of leaflets.

In the previous paper it was suggested that the first notches in the embryonic rose leaf divided the blade from the stipules, and that the leaflets arose in connection with the latter. The mature apple leaf drawn in Fig. 14a indicates that a notch dividing the blade from the stipule developed on one side only. In small apple leaves the stipules are adherent to the petiole much as in the rose; in larger leaves they are cut off as filiform appendages attached by one end. They may still develop into leaflets as shown in Fig. 14b. In Sanguisorba and Poterium, which sometimes show a lobed terminal leaflet, there is evidence of stipular basipetal growth. Thus in *Poterium canadense* a single leaflet or a pair of leaflets may be found close to the stipules and separated by a long stretch of petiole from the more distal leaflets. Sometimes the stipules are scarcely to be distinguished from leaflets, to which they are probably giving rise. Such a leaf is figured by Cushman (*Amer. Nat.*, 1903, vol. 37, p. 354) who states that the lowest pair of leaflets has "almost the character of stipules."

In *Sium cicutaefolium*, which has basifugal pinnate leaves, the



FIGS. 11, *Agrimonia eupatoria* L. 12a–12e, *Rosa lucida* Ehrh. 13a–13b, *Chelidonium majus* L. 14a–14b, *Pyrus malus* L. 15a–15c, *Sium cicutaefolium* Gmelin.— 12e, natural size; 12c, 14a, and 14b, × ½; 12d, 15a, 15b, and 15c, × ⅓; the others, × ¼.

basal leaflets are often joined to the thin sheath-like stipules. In fact the relation of the leaflets to the stipules is strikingly like that in the rose, as shown in Figs. 15a–15c. In the first there is a well developed leaflet proceeding from the stipule on one side, and there is no corresponding opposite leaflet. In the second the stipules are prolonged into small green leaf-like appendages, and in the third the small pair of leaflets above and separate from the stipules suggests a stipular origin. If this is true, leaflets in Sium are added from both ends, and the basal pairs of leaflets are not always homologous as stated by Shull.[1]

Shull's study of Sium supplies an admirably complete record of the leaf-forms presented by a single species. They are, however, considered from the biometric rather than the embryological point of view. Thus the early leaves are divided arbitrarily into six groups or categories. One of these contains the ternate leaves with basally lobed lateral leaflets and three lobed terminal leaflets, — that is, leaves like those of the poison ivy (Fig. 2a) and Negundo (Fig. 5a). This fundamental class which exhibits symmetrically the basipetal and basifugal directions of growth, is described as simply a special case of variously notched three-parted leaves "which was separated from the others only because it could be so definitely characterized." Although Shull includes only 20% of the first leaves of Sium in this category, a large proportion of the forms placed in the remaining five groups are but variations of this type,— the terminal lobes may be suppressed on one or both sides, the basal lobes may be secondarily notched, etc. The study of Sium shows that the leaves at first exhibit both basipetal and basifugal tendencies and that the latter becomes predominant.

SUMMARY.

The leaves of very diverse species show a common method of leaf development in which the basipetal and basifugal directions of growth are combined. This is shown by the widespread occurrence of the ternate leaf with the three lobed apical leaflet and

[1] Shull, G. H. Stages in the development of *Sium cicutaefolium*. Carnegie Inst. of Washington, Publ. No. 30, 1905. 28 pp.

basally lobed proximal leaflets. This form appears with more or less distinctness in *Clematis virginiana, Rhus toxicodendron, Rubus occidentalis, Rubus strigosus, Negundo aceroides, Ailanthus glandulosus,* and *Sium cicutaefolium.* By the predominance of the basipetal or the basifugal element, palmate or pinnate leaves are produced respectively. Twice pinnate leaves develop along the same plan; in becoming twice pinnate a basipetal secondary leaflet becomes matched by a smaller leaflet on the distal border and further development of secondary leaflets in basifugal. This is shown in Sambucus, Aralia, and Cicuta, and the exceptional nature of Bidens is recorded.

The manner of leaf development in the rose requires further study. The formation of leaflets in connection with stipules occurs in Poterium, Sium, and the rose, but in Sium and to a less extent in Poterium they form also from the terminal leaflet. Lobed leaflets in the rose were not found.

Jackson's studies have shown that some Cretaceous leaves are like the simpler stages in the corresponding existing species, notably in the tulip trees. Shull concludes, however, that "no satisfactory inferences can be drawn from ontogenetic leaf-characters regarding the phylogenetic history of the species." He states that there is need of physiological interpretation, and further biometric studies of leaves are being made. In connection with paleontological and biometric studies it is important that the embryology of leaves should be known, not by inference from mature leaves but by reconstructions of the embryonic stages.

The preceding descriptions of adult leaves show that there is a determinate evolution of leaf forms, whereby diverse species tend to produce similar shapes. Plants with simple leaves constantly show tendencies toward compounding. The "obscurely lobed" leaves of *Malva rotundifolia* are occasionally deeply divided, and the notches on the red maple leaf may become clefts extending to the petiole. The persistent production of the similar forms of compound leaves which have been described is evidence in favor of determinate or orthogenetic evolution.

CAMBRIDGE, MASS.

EARTHWORMS AS PLANTERS OF TREES

E. A. ANDREWS

That squirrels aid the forester by burying nuts, some of which may be left to germinate and so start new trees, has long been known; but that common earthworms play a like part in the drama of the woods has not been suspected. The following observations, however, show that the earthworm may be of use in aiding the germination of at least one important kind of tree and raise the question whether they do not do the same for some other trees as well as for many smaller plants.

The earthworm assists in planting by bringing the seeds into close contact with the soil, even burying them. Here, as in the case of the squirrel, the object sought by the animal is not the germination of the seed. The squirrel is following a strong food instinct in hiding away nuts, many of which it will find again and eat; the earthworm is also obeying a very strong instinct, which is, however, only in part a food instinct. This instinct expresses itself in the somewhat mysterious habit the earthworm has of plugging up its burrows.

As is well known, some of our common kinds of earthworms make holes in the ground and inhabit them for long as places of protection from dryness and from various enemies. In the night time, however, these earthworms may leave their burrows more or less completely, to seek on the surface of the ground various objects to be used as food, and to associate with other earthworms. They then seize and eat both live and dead vegetable matter, and soft animal matter when available; and they also drag back to or into their burrows both edible and inedible objects. At times the materials collected at the mouths of earthworms' burrows plug them up most effectively, so as to suggest that the chief purpose of this activity is to close the opening of the burrow after the worm has gone in. Thus one may frequently see tufts of pine needles, of dead brown or of fresh green deciduous leaves, or of other light objects that may have been upon the surface, sticking up here

and there over the ground, each tuft so tightly and completely filling a burrow that one might at first suppose that children at play had deftly thrust leaves into all the earthworms' burrows.

It was this strong instinct to plug up its burrows which Darwin seized upon as a means of enquiry into the mental powers of the earthworm. Scattering triangles of paper over the ground he judged from the way in which these triangles were used by the worm in plugging its burrows that it distinguished between angles of different acuteness and probably exercised something akin to reasoning. In his classic work on the earthworm Darwin does not refer to the possible collection of seeds, though he discusses the plugging instinct at considerable length. He says,—"Worms seize leaves and other objects not only to serve as food, but for plugging up the mouths of their burrows; and this is one of their strongest instincts. Leaves and petioles of many kinds, some flower peduncles, often decayed twigs of trees, bits of paper, feathers, tufts of wool, and horse hairs are dragged into their burrows for this purpose....They often, or generally, fill in the interstices between the drawn-in leaves with moist, viscid earth ejected from their bodies; and thus the mouths of their burrows are securely plugged....When worms cannot obtain leaves, petioles, sticks, etc., with which to plug up the mouths of their burrows, they often protect them by little heaps of stones; and such heaps of smooth, rounded pebbles may frequently be seen on gravel walks...." Darwin was inclined to think that one advantage gained by the earthworms in plugging up their burrows lay in the protection gained from cold night air, from animal enemies, and less probably from rain.

Whatever the utility of this instinct, it is carried out with so great a variety of objects, that it was not surprising to find earthworms plugging their burrows with the dry, flat fruits of the maple tree. On May 30th the ground under several large silver maple trees in Druid Hill Park was thickly sprinkled with the yellow key-fruit, or samaras, that had fallen from these trees, and it was quite noticeable that in many places these fruits were gathered together in little heaps. Each collection of seeds contained form twelve to fifty, some lying loose, others more or less buried in the earth. One of the larger heaps when lifted up filled a hand nearly full.

In some places the heaps were not more than a foot apart, but elsewhere they were more sparsely scattered. When any heap was dug up it was found to be a mass of samaras, bound together with earth and some few fibers, probably dead grass.

The ground about some of the collections of maple tree seeds was markedly free from seeds and clean, so that it seemed as if the worms had reached out of their burrows to nearly their full length of eight or nine inches and dragged back all the seeds they could find in a circular area of which their stretched out bodies made the radius. All this was much more evident in the areas close to the tree trunks where there was little or no grass, while far out from the tree trunks, where the grass was thick, the heaps of seeds were smaller and not so evident, both because of the grass and because there was a more uniform distribution of seeds with a less perfect cleaning up of the neighborhood of each heap.

The earthworms' holes were completely closed by the samaras and earth. When about an inch deep of earth and seeds had been removed the open burrow was seen as a clear hole about as big as a pencil. An imaginary section down through a heap of seeds would show a low cone made of seeds imbedded in earth, covered with some dry, free seeds on the surface, the whole rising an inch or more above the normal surface of the ground and of the upper end of the earthworms' burrow.

It was not determined what species of earthworm made the collections of maple seeds. The few small red earthworms found in some cases lying in amongst the seeds and moist earth that plugged the burrows, probably had nothing to do with the making of the burrows or with the collecting of seeds, though they may have profited by the moist vegetable food and other conditions found in these heaps.

The samaras were for the most part buried so that the flat wing was down and the thick part, containing the seed, uppermost; in fact in many cases it was only the wing that was in the ground. However, in some cases the seed was down and the wing uppermost. Apparently the earthworm had as a rule taken hold of the samara by the flat wing and dragged it with this part foremost. While the samaras lying loose upon the ground were all intact and not injured many of those inside the heaps were frayed and frazzled so that the shorter side of the wing often looked like a comb.

Probably the worms had macerated and eaten off the leaf-like part of the samaras but left the seed end uninjured.

In every collection of seeds some three or four, or more, had sprouted, while outside these collections none of the seeds lying over the ground were found to have sprouted. Most of the sprouting seeds showed merely a short radicle and in the many cases in which the seed end of the samara was above ground the radicle was growing down to enter the earth. Some of the seeds that were well buried had advanced farther; in one case the young stem was three inches long and bore a small expanding plumule.

Though so many young trees were thus started by the aid of earthworms in a situation in which the seeds did not sprout at all unless thus brought into connection with the necessary moisture, few of these seedlings made much further progress, as the conditions were too unfavorable. But even after a long dry hot period, on June 27th, some dozens of young trees were found scattered over the bare ground under the more densely shading parts of the mother trees, where they were not destroyed by the lawn mowers as completely as were any that started to grow in the grass. These little trees were three to four inches in height; the cotyledons were shrivelled while two or three pairs of leaves of maple shape were now in evidence. Some of the trees were in groups with remnants of old decayed samaras about them to indicate the former mound of earth, since washed away. The many trees standing isolated were deeply implanted in the ground and probably stood where earthworms' mounds had been. A photograph taken then shows six or seven little trees of different sizes all rising up close together from one old heap of samaras. Even these favored few did not survive the increasingly adverse conditions, for on August first, when the hard dry ground under the parent trees was marked by radiating, branching streaks of brown grass that had died over their old superficial roots, all the seedling trees had disappeared.

The failure of this particular planting, under such conditions, does not, of course, invalidate the contention that in nature the earthworms may play quite an important part in forestry. They probably more than amend, by planting trees, the damage with which they are credited through destroying seedlings in gardens.

JOHNS HOPKINS UNIVERSITY
Baltimore, Md.

THE CAUSE OF GYNANDROMORPHISM IN INSECTS

T. H. MORGAN.

In recent years many cases have been recorded in the group of insects in which parts of the body show the characters of the male and other parts those of the female. Most frequently the separation lies along the middle line of the body, so that one side is like the male and the other like the female. About two years ago I attempted in the case of the bee to correlate this result with the well known frequency of dispermy of the insects' egg.[1] Two spermatozoa having entered, one fuses with the egg nucleus and its products produce the female characters; the other develops alone and gives the characters of the male to the parts of the body it supplies with nuclei, etc.

That the latter assumption is not arbitrary is shown by experiments with the egg of the sea-urchin in which it has been possible to fertilize a non-nucleated piece of the egg with a single spermatozoon. Boveri has attempted to prove that under these conditions the characters of the larvae are paternal, which is in accord with our hypothesis for the bee. The evidence however on which Boveri's conclusion rests has been disputed. More recently Godlewski has succeeded in cross-fertilizing a non-nucleated fragment of the egg of a sea-urchin with the sperm of a crinoid. The characters of the young larvae are said to be maternal, indicating that the protoplasm rather than the nucleus is the controlling factor in determining the characters, but Godlewski's statements apply only to the very earliest stages of development, where according to Driesch's results the maternal influences predominate.

A test of the view that I have suggested should be found for the bee if a gynandromorph should arise in a cross between two species; for, on my hypothesis those parts that develop from the combined nuclei should be female and hybrid in character, while those that come from the single nucleus of the spermatozoon should be male

[1] Morgan, T. H. An Alternative Interpretation of the Origin of Gynandromorphous Insects. *Science*, 1905, vol. 21.

and paternal in character. The most remarkable case of gynandromorphism that has ever been described, namely, that of the Eugster hive, resulted from a cross between two species of bees, but it is impossible to tell from von Siebold's description the specific characters of the male and female parts. A test case is apparently furnished in a recent paper by Toyama[1] "On Some Silk-worm Crosses with Special Reference to Mendel's Law of Heredity." Since Toyama has not attempted to draw any conclusion from the interesting cases that he has found I venture to call attention to their possible interpretation.

A cross was made between two races of silk-worm moths; the female belonged to a European breed having striped caterpillars; the male belonged to the common Japanese breed having plain, *i. e.* not striped, caterpillars. Two of the hybrid caterpillars had the left side of the body striped (maternal) and the right side plain. Applying my hypothesis to this case we see that the striped side is due to the combined nuclei — the striped character carried by the egg dominating the plain character of the sperm-nucleus; the plain side is due to the sperm nucleus alone and is therefore paternal.

It might possibly be objected that the striped race was not pure but produced some plain germ cells, so that the right side is due to this condition; but there is no evidence that the striped race is impure in this respect and the many experiments made by Toyama with this race would have shown the impurity had it existed.[2] Moreover the striped condition of the left side shows that the egg of this individual must have carried striped characters since this character is not carried by the sperm.

Boveri suggested a different interpretation of gynandromorphism. He assumed that the results are due to the single sperm, that enters, fusing with one pole alone of the segmentation spindle derived from the egg nucleus. Toyama's case offers an opportunity to test whether Boveri's or my own hypothesis applies here. For ex-

[1] Toyama, K. Studies on the Hybridology of Insects. I. On Some Silk-worm Crosses, with Special Reference to Mendel's Law of Heredity. *Bull. Col. Agric. Tokyo Imperial University*, 1906, vol. 7.

[2] The striped race was found, however, to be impure in another respect. It may produce a pale form but the occurrence of the pale form has no bearing on our conclusion.

ample, according to Boveri's view the single nucleus (that supplies the male parts in the bee) is derived from the egg which in the present case contains the striped character; the other side is derived from the combined nuclei which should also the striped in the present case since this is the dominant; but the facts are contradictory to the hypothesis. On the other hand the facts are what my hypothesis calls for.

So far I have attempted to consider Toyama's cases without regard to the question of the sex of the right and left halves because while this raises some even more interesting issues, the conclusions are more problematical, since we do not know in the moth the nature of the factors that determine sex. Several possibilities must be considered. If however we are justified in extending the conclusion reached above in regard to the origin of these gynandromorph — a conclusion I repeat, that is reached independently of the question of sex — to the case of the bee, where more is known in regard to sex determination, we shall be led to some far reaching and important considerations concerning sex determination.

The moth that emerged from Toyama's gynandromorph caterpillar had on the left striped half of the abdomen, external female reproductive organs; and on the right plain half, male organs. In my view the right side has come from the single spermatozoon. It has produced the male sex. Two interpretations are here possible. If there exist in the silk-worm moth two kinds of spermatozoa — male and female producers — as shown by Stevens and Wilson for some other insects, the right side may be due to a male-producing (arrhenotokous) spermatozoon; while the opposite female side would be due to a female-producing (thelytokous) spermatozoon having fused with the indifferent (?) egg nucleus. On the other hand the results may be due to a single nucleus alone being capable of forming the male characters only. The evidence, even for the egg is not clear for the moths, for while cases have been described in which only females appear from unfertilized eggs, there are other cases in which both males and females developed. Until we know something of the behavior of the polar bodies in these cases it is unsafe to draw any conclusion in regard to the eggs, and much more so in regard to the spermatozoa.

In the case of the bee these conditions are better understood. It appears as a rule that all unfertilized eggs produce males, and all fertilized eggs produce females. The latter result must be due to all the sperm being female producers, or to only female sperm being capable of entering the egg, or to a quantitative relation, namely, the combined nuclei producing female characters and the single nucleus producing male characters. If we are justified in extending to the bee the conclusion reached above for the moth we can decide amongst these three interpretations. If the gynandromorphous bee is due to one sperm nucleus fusing with the egg nucleus and one (or more) sperm nucleus failing to fuse but developing alone, then the sperm are not female-producing but alone are male-producing. The egg nucleus alone is also male-producing as seen in the development of drones. Combined, however, these two male-producing nuclei give rise to a female-producing nucleus. If this conclusion proves to be correct it throws an interesting light on one of the ways in which sex determination is accomplished.

Equally important is the conclusion to which we are led in regard to the relative influence of the spermatozoon versus that of the egg-protoplasm — a question, as we have seen, on which the experimental embryological evidence is still in doubt. The sperm supplied with egg protoplasm gives rise *in the adult* to paternal characters only, even in those cases like the present one in which the egg carries the dominant characters! If we think of the spermatozoon as introducing a nucleus only, the paternal characters may be attributed to the nucleus; if we think of the spermatozoon as introducing also some cytoplasm — the centrosphere for example — the results might be supposed to be due either to the introduced nucleus, or to the introduced cytoplasm, or to both. Since however the egg also supplies cytoplasm (and that of the dominant kind in the present case) this would offset that of the spermatozoon. It seems therefore that the nucleus is the essential factor. Thus our analysis furnishes a clue as to what part of the sperm carries the factors that determine the characters of the adult organism.

COLUMBIA UNIVERSITY, NEW YORK
Sept. 15, 1907

NOTES AND LITERATURE

GENERAL BIOLOGY

Mental Development in the Child and the Race.[1]—"Then there are the biologists — one almost despairs of them! Are there any yet born to follow the two I have named (Spencer and Romanes) in finding mind as interesting as life?" Professor Baldwin has not been compelled to repeat in the new edition of his stimulating book the statement which we have quoted from the preface to his first edition, for, as he remarks, the ten years since it was written have witnessed a remarkable change in the attitude of biologists toward psychology. The truth is that not a few of the leaders in biological science have read Professor Baldwin's book and have found in it excellent reasons for opening their minds to the results of the scientific investigation of consciousness. It is to be hoped that many more of them will read the new edition of "Mental Development" critically and with a view to bringing the author's facts, principles, and theories into relation to the pre-eminently important problems of heredity which now occupy the attention of so many biologists.

Since, on its appearance ten years ago, "Mental Development" received many lengthy review notices it is not fitting that we should fully describe the content of the new edition. The author in revising his book has introduced a number of minor changes, but the work stands essentially as it was originally written. For the benefit of those who may desire a more complete statement of Professor Baldwin's views than can be obtained by a reading of the volume under consideration we may say that three other books are now available: "Social and Ethical Interpretations," "Development and Evolution," and "Thought and Things."

R. M. YERKES.

Racial Descent in Animals.[2]— Since the general acceptance of the

[1] Baldwin, James Mark. Mental Development in the Child and the Race: Methods and Processes. With seventeen figures and ten tables. Third edition, revised. New York, The Macmillan Company. 1906. Pp. xviii + 477.

[2] Montgomery, T. H., Jr. The Analysis of Racial Descent in Animals. Henry Holt and Co., New York, 1906, xxi + 311 pp.

theory of descent with modification, the exact genealogical relationship of animals has been an ever recurring question. In one way or another it seems to have fascinated certain workers. With the superficial, it takes the form of arrangements of living species in what is assumed to be a genealogical sequence without regard to the fact that these animals are of the same generation, so to speak, and not ancestrally related. Speculations of this kind have brought much of this work into disrepute. With the serious-minded, attempts have been made to ascertain the principles by which kinship among animals can be determined, and to this class belongs the volume under consideration.

With much care and erudition Montgomery has sought for a sound basis by which animal relationship can be ascertained. This he has formulated in a series of principles as follows: first, evidence of kinship must be sought in the physiological as well as the morphological relations of animals, for these two provinces are in reality mutually interdependent; secondly, all the factors concerning animal processes must be scrutinized; thirdly, the relative value of the different kinds of evidence must be considered; fourthly, monophyletic origins should be assumed unless the opposite can be proved; fifthly, approximately intermediate connectants between species should be anticipated; sixthly, organic modification is a response on the part of the organism to a change in the environment; seventhly, comparisons between diverse organisms are, at best, of the nature of inexact homologies; and finally, the unit of comparison is the individual during its whole life and not at any arbitrarily chosen stage.

It is noteworthy that two classes of evidence much in vogue in the discussion of questions of this kind are belittled by Montgomery. According to him no special light is thrown by embryology on phylogeny, for the development of the individual does not in his opinion recapitulate the development of the race; and the evidence brought forward by paleontology is too fragmentary to be of any service. While it can frankly be admitted that the eight principles enunciated above are worthy of serious consideration in the determination of phylogenies, it is by no means clear that they are of prime importance as compared with certain others; for, notwithstanding the lengthy argument adduced by Montgomery, ontogeny may still vaguely outline phylogeny. The fact that the appearance of a new character in a species involves a change that must influence the whole life cycle of the animal from the egg to the adult does not necessarily blot out other more ancient characters that may appear only at certain stages

and that may recall an adult state of an early ancestor. Moreover it cannot be denied that the fossil record, meager though it is, is the real record, whereas any scheme evolved in accordance with the eight principles already named must remain, if untested by the fossil record, forever hypothetical. How little we would know of the real characters and genetic relations of the reptiles or of the mammals if we limited ourselves to these principles. But, it might be retorted, that granting what has been said about reptiles and mammals what light does the fossil series give us on the interrelations of such groups as the animal phyla, and to this question it must be admitted that no satisfactory reply can be made. But is it perhaps not well to confess at once complete ignorance of a question which from its very nature can receive only such an answer as will remain forever hypothetical? The reviewer is inclined to believe that it is.

G. H. Parker.

Hough and Sedgwick's Physiology.[1] — The volume under consideration is a reprint of the first half of "The Human Mechanism," by the same authors. The latter has been favorably reviewed in the *Naturalist* for March of this year (p. 194). The "Physiology" is an excellent text-book for high school grades, and since further editions will undoubtedly be called for, it is perhaps desirable to suggest that more attention might profitably be given to anatomy, upon which physiology is to some extent founded. The authors state that "in the present book anatomy has been reduced to its lowest terms and microscopic anatomy or histology has been touched upon only as far as seemed absolutely necessary." Some of the anatomical references which might be improved are as follows. On p. 167, "alveolus" is used for "lobule" of the lung; and "air cell" for "alveolus." The thyreoid gland, a median, bilobed structure, is described as "two small organs which lie in the neck, one on each side of the trachea" (p. 66). The red corpuscles are said to be "biconcave disks" (p. 135) although they are now generally considered to be cup-shaped, with a small proportion of spherical forms; they vary in shape, but the biconcave form is not characteristic of circulating blood. Occasionally an unnecessary term is introduced, — "sarcostyle" is not better than muscle fibril or myofibril, and "synapse" is not, for high school scholars, an improvement upon terminal branches. (Neither sarcostyle

[1] Hough, T. and Sedgwick, W. T. Elements of Physiology. Boston, Ginn & Company, 1907. 12mo, 321 pp., illus. $1.25.

(Schäfer) nor synapse (Foster) are in very wide use at present.) Generally, however, the book shows that the authors had in mind the immature student, as when they state that "the surface area of all the red corpuscles of the blood is 3,000 sq. meters or approximately four times the size of a baseball diamond." On the whole it is a book excellently adapted to its purpose, and in its present form it can be still more widely used.

F. T. LEWIS.

ZOOLOGY

The Nervous System of Vertebrates.[1] — Bell's discovery that the dorsal roots of spinal nerves in vertebrates are sensory and the ventral roots motor in function may be said to be the first step in subdividing the nervous organs of these animals into physiological regions. This process has been very much extended recently especially by certain American neurologists with the result that the nerves and central organs of vertebrates have come to be considered as aggregations of elementary systems of fibers essentially homogeneous from a physiological standpoint. The observations upon which this conception is based are contained for the most part in special papers and have not heretofore been collected and condensed into a single readable account. Such an account has been attempted by Johnston in his text-book on the vertebrate nervous system.

The introductory chapters of this work treat of the morphology, development, and physiology of the nervous system, after which its parts are dealt with, not as in most text-books from the topographical standpoint, but from that of physiological components. Chapters are devoted in sequence to the somatic afferent division as represented by the nervous mechanism concerned with touch, the lateral line organs, and the ear; to the visceral afferent division as represented by the visceral sensory apparatus and the organs of taste; to the somatic motor division controlling the skeletal musculature; and to the visceral afferent division concerned with the visceral musculature, etc. These chapters are followed by others dealing with special centers: the cerebellum, mesencephalon, diencephalon, and cerebral hemispheres.

[1] Johnston, J. B. The Nervous System of Vertebrates. P. Blakiston's Son & Co., Philadelphia, 1906, xx + 370 pp., 180 illustrations.

Although this method of subdividing the nervous organs and classifying their parts has many points of advantage over the older topographical method, it possesses as elaborated by Johnston its weaknesses and these are most clearly seen in the way in which certain organs of special senses are dealt with. The eye and its nervous connections are put in the somatic afferent division not because they are concerned with touch or any of the derived senses, but because in certain of the lower vertebrates the spinal nerve terminals are stimulated apparently by light. The olfactory apparatus is classed under the visceral sensory division because it is concerned with the acquisition of food. The weakness of this classification is apparent from the fact that the reasoning by which the author is led to assign the olfactory apparatus to the visceral sensory division, if applied to the optic apparatus, would bring these organs under that head instead of under the somatic sensory. In a similar way the organs of taste ought not to be classed as visceral sensory organs but as a somatic sensory mechanism, for the reason that the cutaneous sensory nerves of the lower vertebrates are stimulated by sour and salt substances much as our organs of taste are. In other words the classification proposed by Johnston and others, though avowedly physiological, will not stand the test of even the most elementary physiological facts. This state of affairs is probably due to the common practice of certain neurologists of assigning physiological significance to a part on the basis of purely morphological considerations and without once endeavoring to ascertain by experiment the real function of the part concerned. A detailed classification based upon such a method as this is bound to be erroneous and as in this movement the classification epitomizes results, a complete change of method must be inaugurated before sound conclusions can be arrived at. Johnston's book, though a praiseworthy effort, is characterized rather by an enthusiasm for a novel system of classification than by an appreciation of the weaknesses of this system.

G. H. Parker.

The Sense of Touch in Mammals and Birds.[1]— The title of this volume is too inclusive, as is stated by its author in the introduction. It is essentially an anatomical account of epidermal markings and the papillae of the corium; other tactile organs are not considered. The first part of the book discusses palms and soles macroscopically.

[1] Kidd, Walter. The Sense of Touch in Mammals and Birds. London, Adam and Charles Black, 1907. 176 pp., 164 figs. Also The Macmillan Co., New York. $2.00.

Eighty-six mammals and eleven birds were examined. Cutaneous *ridges* were found to reach their full development only in primates. The coarse walking pads of the large carnivora consist of *rods*, a feature found also in the marsupial wolf of Tasmania, and to some extent in the eagle. The plantar surface of the other birds studied was merely corrugated, like that in Ornithorhynchus, Echidna and fourteen other mammals. Scaly palms and soles occurred in nine of the eighty-six mammals; smooth epidermis was found only in Proteles, and a complete covering of hair only in the rabbit. The palms and soles of the primates are then described in detail, with numerous figures.

The second part of the book deals with the form and arrangement of the papillae of the corium, and is illustrated from sections magnified generally fifteen or twenty diameters. Since half-tone text-figures will not print well on paper with a rough surface, such as is used in the first part of the book, the publishers have printed pages 81–144 on glazed paper. The volume concludes with a physiological discussion, a summary, and an extensive bibliography.

F. T. LEWIS.

Observations on the Young of the Red Kangaroo.— A red kangaroo, *Macropus rufus* (Desm.), was born in the Barnum and Bailey menagerie a short time before I became their zoologist, which was in March, 1904. At that time it was just beginning to put its head out of the pouch. The superintendent insisted that he had known of its presence in the pouch for two months and thought it must have been a month old when he first discovered it. About a month after my arrival the little fellow began coming out. Four months seems rather long for the young to remain in the pouch before beginning to come out, in view of their very rapid growth, but the period cannot be less than two months, and is probably three or even more. A month after beginning to come out, he would still rush back on the slightest provocation, going in head first and turning round, but leaving his tail and long hind legs protruding eighteen or twenty inches. In this position he presented a very comical picture.

The kangaroo, in common with other marsupials, is of a very low order of intelligence, and yet this mother was very solicitous for the safety and welfare of her son. At first she gently objected to his coming out, holding him in the pouch with her fore paws. But his budding curiosity and growing activity could not be suppressed and his excursions into the outer world became more and more frequent. At first she would restrain him with her paws from going to the far

side of the cage, keeping him close to her side. The father was permitted to share the cage, but never made any attempt to harm his offspring. On the other hand, he showed no affection for him. From the very beginning the baby displayed the brick-dust red of the father. As is well known, it is no unusual sight, when a herd of kangaroos is feeding, to see the head of the baby protruding from the mouth of the pouch, nibbling grass. I have seen the young eating in this way in captivity.

W. H. Sheak.

A Note of the Prairie-dog Owl which resembles the Rattlesnake's Rattle.— In the summer of 1904 a party of fossil hunters, with four horses (two under the saddle and two hitched to the wagon), was trailing across Wyoming, at the time following up Bridger Creek, a tributary of Bad Water River. As they were moving along an old fence, under and to either side of which were numerous prairie-dog holes, mostly deserted, suddenly a "rattle" caused all four horses to shy out of the road. The saddle horses were brought back, and their riders searched through the low sage bushes and grass for the rattlesnake to kill it. A second warning followed and a prairie-dog owl rose, flying to a fence post some ten feet away, where it alighted and began a third "rattle," and this time all saw its stretched neck, bulging eyes, open beak and vibrating tongue. The whole appearance of the bird indicated assurance that it would thus frighten off any enemy; and it certainly deceived the four plains-bred horses, as well as the men, all of whom had for weeks been familiar with rattlesnakes, and two of them for years. The writer has often been startled by the rattle of the dry lupine pods, known as "rattle weeds," but horses are not so deceived. However they were clearly frightened by the owl.

The usual note of the burrowing or prairie-dog owl, *Speotyto cunicularia* (Mol), is generally described as a squawk, and is not unlike qua-qua-qua-qua, with variations in the last part. Generally the bird is silent, uttering its note only when startled. The unusual rattle of the individual described was heard repeatedly, for we camped about a mile above the prairie-dog holes, and each succeeding day for over a week some or all of the party passed the spot. The owl never failed to warn with its rattle and the horse or horses, no matter how tired, never failed to shy out of the road,— never having associated the rattle with the owl. After ten days the party moved camp and no more was seen of the owl, but it doubtless kept on rattling and deceiving animals

and men. If it succeeds in teaching the trick to its young, a protective habit of great value will be formed.

F. B. LOOMIS.

Feathered Game of the Northeast.[1]— In a volume of 432 pages Walter H. Rich, "a keen sportsman," has written of game birds for the man "whose nature study has been conducted .... mostly over a gun-barrel." He hopes that the scientific ornithologist as well, may find its pages of interest and profit. There are eighty original, full-page half-tone pictures of the birds, which are unusually life-like and in which color contrasts are well brought out. There are also a few hunting scenes, and one drawing in color presenting a pair of wood ducks. The descriptions of the birds are informal, and the author's joy in killing them is undisguised. He admires the woodcock's "lead-carrying grit," and a typical anecdote concludes,— "So the war went on until a lucky shot tumbled the bird from his perch minus half his head." Flavors of the birds are discussed as follows,— "The Sora Rail is usually introduced to the epicure in the form of a pie, and it is in this stage that it makes its best showing"; of the solitary sandpiper he says,— "I think he makes a good impression when, after being skinned, wrapped in a thin piece of fat pork and enclosed in a big potato, he has been well baked." The spruce grouse is "a pretty fowl for a dining room 'bird piece.'" The shooting of whistlers is enthusiastically described. These ducks are now protected within Boston's limits and during the winter they give pleasure to hundreds of people who cross the Charles River daily. Their former destruction, as seen by the genial Autocrat, led him almost to lose his temper, for he wrote,—

> He knows you! "sportsmen" from suburban alleys,
> Stretched under seaweed in the treacherous punt;
> Knows every lazy, shiftless lout that sallies
> Forth to waste powder — as *he* says, to "hunt."

In presenting this book the publishers announce that it contains a "timely plea for moderation in seeking game." Brother sportsmen are asked to paste in their hats the motto "Don't forget to leave enough for seed." The author says that "the Whistlers seem to be holding their own in the struggle for existence — a thing which can be said of few of the duck family" and that "indeed it is a matter for wonder

[1] Rich, W. H. Feathered Game of the Northeast. New York, Thomas G. Crowell & Co., 1907. 8vo, 16 + 432 p., illus. $3.00.

that the shore-birds were not exterminated long ago." He would stop spring shooting and close our markets to the sale of game. We wish that the 'great brotherhood of sportsmen' would agree to this. Their attempt to pose as 'lovers of bird life,' as ornithologists, or as 'Roosevelt-like' is unsuccessful; and if our author really desires to "work loyally in an effort to save our wild life from the extermination which threatens," will he continue to destroy it?

F. T. Lewis.

Game Laws for 1907.— *Farmers' Bulletin 308* of the U. S. Dept. of Agriculture presents a summary of the game laws of the United States and Canadian Provinces. In the number of bills introduced and in the general demand for change of some sort the record of 1907 is second to that of no previous year, although the number of bills actually passed was equaled by the legislation of 1905. Most of the changes were made to secure greater protection. In several states the seasons were closed entirely for certain kinds of game. On the other hand in many places certain restrictions were removed. The legislation is said to be in a transition stage; settled policies have not been determined but various compromises are made between the sportsmen, the ornithologists' unions, and the majority of people with whom such legislation is by no means an issue. Thus these laws are abitrary, complex, and difficult of enforcement. Hunting is prohibited in some Maryland counties on election day; water-fowl are protected on Mondays in Ohio. A Maine license which requires $5.00 ordinarily for the shipment of a moose, etc., permits shipment to a hospital. Alaska allows the sportsman 25 shore birds a day, whereas Maine permits 15 ducks and 70 sandpipers. Such whimsical laws cannot be permanent, and the study of the situation now being conducted should lead to their improvement. Many measures, last year, were allowed to fail rather than pass in an unsatisfactory form.

F. T. Lewis.

Notes on the Structure of Insects.— *The Ovaries of the Hemiptera.*— In a recent review the writer referred to the two opposing views regarding the development of the sex-cells in the ovaries of insects. As is well known, each ovary consists of a variable number of egg-tubes opening into the oviduct. Each tube is divided into three zones: 1st, the *terminal filament* which, uniting with those from neighboring tubes, forms the suspensorium of the organ; 2nd, the *terminal chamber* and, 3rd, the *germarium* or chambered egg-tube.

According to the more generally accepted view the terminal chamber contains the undifferentiated elements from which are derived not only the eggs but the nutritive cells and the cells of the follicular epithelium which surrounds the developing eggs. Korschelt, who is widely quoted, formerly believed that these elements might be traced back still further to indifferent elements of the terminal filament.

Sharply opposed is the view that the sex-cell is *sui generis*, in origin entirely distinct from the surrounding epithelium. This interpretation has been gaining ground but is opposed by Marshall's recent results.

In view of the conflicting conclusions of previous investigators the recent work of Köhler[1] is of much interest. The fact that the work was done under Professor Korschelt's supervision adds especial weight to the author's conclusions.

The contradictory results obtained by previous workers are due mainly to the use of mature specimens, and to poor technique (staining, fixation, or to thickness of sections). Köhler has studied sixteen species of Hemiptera, of most of which he had immature as well as mature stages. Of three species he had a series of the nymphal stages. Fixation was by means of Hermann's or Zenker's fluids, as alcohol or the much-used corrosive sublimate were wholly unreliable.

It was found that the cells of the peritoneal epithelium, the terminal filament, the epithelium of the germarium and of the follicles, are of common origin. These somatic cells are perfectly distinct from the sex-cells and the nutritive cells which are derived from the latter. The germarium is filled exclusively by the germ cells and is always sharply set off from the terminal filament, usually by a distinct membrane. There are no "free nuclei" present.

Köhler's investigation was not confined to the question of the origin of the cells but included a thorough study of the histological structure of the ovaries, and an especial consideration of cell-division. He found that cell-division takes place in the peritoneal epithelium, terminal filament, egg-tube, and germarium and is always by mitosis. On the other hand the so-called amitotic division occurring in the follicular epithelium is confined to the nucleus and never leads to cell-division. However, the tissue in which it occurs is not senile, but living, and capable of growth and activity. Only after the nuclear divisions have occurred begins the cell activity (secretion of egg-chorion)

[1] Köhler, A. Untersuchungen über das Ovarium der Hemipteren. Zeitschr. w. Zool. 1907, lxxxvii, pp. 337–381, pls. 19–20.

which leads to a wearing out of the tissues. Thus the so-called amitosis is not concerned with cell-increase but leads to increase in surface area of the nucleus, the center of cell-activity.

The origin of the adipose tissue of the adult fly.— In most insects the larval adipose tissue persists in the imago, presenting at most slight modifications. In the higher Diptera, however, and especially in the Muscidae, it has been found that the larval fat-tissue disappears completely and is replaced in the adult by a new tissue. This Berlese thought to be derived from the nuclei of larval muscles, while Henneguy regarded it as made up of metamorphosed leucocytes.

Perez,[1] '07, describes a condition much more in harmony with what is known concerning the origin of other adult organs and tissues. According to this investigator the fatty tissue of the adult originates from subhypodermal groups of small, compact, mesenchymatous cells which, like all young cells, stain readily in haematoxylin. These groups are thus the homologues of the imaginal disks.

The influence of nutrition on reproduction in a spider.— Lecaillon,[1] '07, finds that the conditions of nutrition strikingly influence egg production in a common spider, *Agelena labyrinthica.* Ordinarily this species constructs a single cocoon, containing from 50–100 eggs. Occasionally double cocoons are to be found, one capsule containing a much smaller number of eggs. By overfeeding, Lecaillon obtained from one female five cocoons in as many weeks. Four of these contained respectively 78, 38, 14, and 5 eggs while the fifth cocoon was small, irregular and empty.

W. A. Riley.

Notes.— The so-called double heart of the mollusk Arca has been made the subject of special investigation by A. Theiler (*Jena. Zeitschr. f. Naturwiss.*, Bd. 42, pp. 115–142, Taf. 9–10). The author points out that it is only proper to speak of a double heart where each ventricle has a separate aorta and acts independently of its fellow. Such a condition occurs in *Arca noae, A. barbata, A. tetragona,* and *A. lactea.* In *A. lactea,* however, there is a common pericardium for both ventricles

[1] Perez, Ch. Origine du tissu adipeux imaginal chez les Muscides. C. R. Soc. Biol. 1907, lxiii, pp. 137–139.

[1] Lecaillon, A. Influence de la nutrition sur la reproduction d'Agelena labyrinthica Cl. C. R. Soc. Biol. 1907, lxii, pp. 334–337.

and in *A. scapha*, according to Ménégaux, there is not only a common pericardium but the two ventricles are represented by one. Thus in different species of Arca there occurs all transitions from a single to a double heart.

After an extended consideration of the musculature of the gorilla in comparison with that of man and the lower apes, Dr. A. Sommer (*Jena. Zeitschr. f. Naturwiss.*, Bd. 42, pp. 181–308, Taf. 25–28, 1906) concludes, contrary to the opinion of Huxley, that the gorilla in this part of its structure is more closely related to the lower apes than to man. P.

Two large frogs from South Kamerun, West Africa.— The University Museum, University of Michigan, has recently received, in a very interesting collection made by Mr. George Schwab from the vicinity of Efulen, Kribi, Kamerun, West Africa, a specimen each of the Giant Frog, *Rana goliath* Boulenger, and the Hairy Frog, *Trichobatrachus robustus* Boulenger. Both of these specimens agree closely with the descriptions recently published by Mr. Boulenger (*T. robustus* Proc. Zool. Soc. Lond., May 8, 1900, 443; *R. goliath*, Ann. & Mag. of Nat. Hist., XVII, 317–318, and Proc. Zool. Soc. Lond., I, 179). *R. goliath* enjoys the distinction of being the largest frog known, and the above mentioned specimen only slightly exceeds in size the one described by Mr. Boulenger. From snout to vent it measures 300 mm., but Mr. Schwab, the collector, states that *it is only partly grown*. He writes of its habits as follows: "This frog lives only in rivers, about the rocky shores of deep pools. On the slightest provocation it dives away, making it difficult to secure specimens."

Alexander G. Ruthven.

PUBLICATIONS RECEIVED

From September 1 to October 1, regular exchanges not included
The year of publication when not otherwise noted, is 1907

ANDREINI, A. L. *Sfere Cosmografiche e loro Applicazione alla Risoluzione di Problemi de Geografia Matematica.* Milan, Ulrico Hoepli, 1907. XXX + 328 pp., 12 figs. L. 3.— KIDD, W. *The Sense of Touch in Mammals and Birds.* London, Adam and Charles Black, 1907. 176 pp., 174 illus. $2.00.— MAGRINI, G. P. *Lo Studio Scientifico dei Laghi.* Milan, Ulrico Hoepli, 1907. XVI + 242 pp., 53 figs. L. 3.— OLCOTT, W. T. *A Field Book of the Stars.* New York, G. P. Putnam's Sons, 1907. 163 pp., 50 diagrams.— RICH, W. H. *Feathered Game of the Northeast.* New York, Thomas Y. Crowell & Company, 1907. 8vo, 450 pp., 87 illus. $3.00.

ADAMS, G. E. A study of Rhode Island soil requirements, by means of field tests. *R. I. Agric. Exp. Sta.*, bull. 121, pp. 141–175.— BRUNER, H. L. On the cephalic veins and sinuses of reptiles, with description of a mechanism for raising the venous blood-pressure in the head. *Amer. Jour. of Anat.*, vol. 7, no. 1, pp. 1–117, 17 figs., 3 pls.— CLARK, A. H. Descriptions of new species of recent unstalked crinoids from the north Pacific Ocean. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 69–84.— CLARK, A. H. Descriptions of new species of recent unstalked crinoids from the coasts of northeastern Asia,— *Proc. U. S. Nat. Mus.*, vol. 33, pp. 127–156.— COCKS, R. S. The flora of the Gulf Biologic Station. *Gulf Biol. Sta.*, bull. 7, 42 pp.— EDWARDS, C. L. The Holothurians of the north Pacific coast of North America, collected by the Albatross in 1903. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 49–68.— EIGENMANN, C. H., AND FLETCHER, O. An annotated list of Characin fishes in the United States National Museum and the Museum of Indiana University, with descriptions of new species. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 1–36, 8 figs.— ELLIOT, D. G. A catalogue of the collection of mammals in the Field Columbian Museum. *Field Columbian Mus.*, zoöl. ser., vol. 8, 694 pp., 92 figs.— GARCÍA, F. Melon Culture. *N. Mex. Agric. Exp. Sta.*, bull. 63, 38 pp., 10 figs.— GIRTY, G. H. Descriptions of new species of upper Paleozoic fossils from China. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 37–48.— HARE, R. F., AND GRIFFITHS, D. The tuna as a food for man. *N. Mex. Agric. Exp. Sta.*, bull. 64, 88 pp., 7 pls.— HARRIS, J. A. Prolification of the fruit in Capsicum and Passiflora. *Rep. Mo. Bot. Gard.*, vol. 17, pp. 133–145, 3 figs.— HARRIS, J. A. Ascidia in Gasteria and Agave. *Rep. Mo. Bot. Gard.*, vol. 17, pp. 126–132, 6 figs.— HARTWELL, B. L., AND COOK, C. L. Soil tests in paraffined wire baskets, compared with tests on farms. *R. I. Agric. Exp. Sta.*, bull. 120, pp. 111–138, 2 figs.— HARTWELL, B. L., MORGAN, J. F., WHIPPLE, L. F. AND HAMMOND, H. S. Analyses of commercial fertilizers. *R. I. Agric. Exp. Sta.*, bull. 122, pp. 179–187.— HUS, H. Fasciation in Oxalis crenata and experimental production of fasciations. *Rep. Mo. Bot. Gard.*, vol. 17, pp. 147–152, pls. 17–19.— KELLOGG, R. S. Exports and imports of forest products: 1906. *U. S. Dept. of Agric.*, forest service, circ. 110, 28 pp.— KIRKALDY, G. W. Leaf-hoppers — supplement.

Div. Ento., Exp. Sta. Hawaiian Sugar Planters' Assoc., bull. 3, 186 pp., 20 pls. — MANN, H. H. Individual and seasonal variations in Helopeltis theivora, with description of a new species of Helopeltis. *Mem. Dept. of Agric. in India*, ento. ser., vol. 1, no. 4, pp. 275–337, pl. 15.— MAXWELL-LEFROY, H. The more important insects injurious to Indian agriculture. *Mem. Dept. of Agric. in India*, ento. ser., vol. 1, no. 2, pp. 113–252, 80 figs.— MAXWELL-LEFROY, H., AND GHOSH, C. C. The Indian surface caterpillars of the genus Agrotis. *Mem. Dept. of Agric. in India*, ento. ser., vol. 1, no. 3, pp. 253–274, pl. 14.— ORTON, W. A. Sea Island cotton: its culture, improvement, and diseases. *U. S. Dept. of Agric.*, farmers' bull. 302, 48 pp., 13 figs.— PALMER, T. S., OLDYS, H., AND BREWSTER, C. E. Game laws for 1907. *U. S. Dept. of Agric.*, farmers' bull. 308, 52 pp.— RAMALEY, F. Trees of the pine family in Colorado. *Univ. of Colorado Studies*, vol. 4, no. 2, pp. 109–122, 2 figs.— RAMALEY, F. The poplars, aspens and cottonwoods. *Univ. of Colorado Studies*, vol. 4, no. 3, pp. 187–197, 6 figs.— RAMALEY, F. The Tokyo Botanical Garden. *Plant World*, 1906, vol. 9, no. 11, pp. 251–258, pls. 40–43.— SWEZEY, O. H. The sugar cane leaf-roller. *Div. Ento., Hawaiian Sugar Planters' Assoc.*, bull. 5, 60 pp., 6 pls.— VEITCH, F. P. Chemical methods for utilizing wood. *U. S. Dept. of Agric.*, bur. of chemistry, circ. 36, 47 pp., 16 figs.— VERNON, J. J. AND SCOTT, J. M. Pig feeding. *N. Mex. Agric. Exp. Sta.*, bull. 62, 20 pp., 4 pls.— WEBSTER, F. M. The spring grain-aphis or "green bug." *U. S. Dept. of Agric.*, bur. of ento., circ. 93, 18 pp., 7 figs.

AGRICULTURAL COLLEGE, N. M., College Record, vol. 1, no. 2.— ELEVENTH ANNUAL REPORT OF THE STATE ENTOMOLOGIST OF MINNESOTA, 1906.— LA CUNA DE AMERICA, vol. 2, nos. 30 and 31.— MICHIGAN COLLEGE OF MINES, Year Book for 1906-1907.— NATURAE NOVITATES, nos. 9, 11, 12, 14.— NEW MEXICO COLLEGE OF AGRICULTURE AND MECHANIC ARTS, Seventeenth Annual Report, 1905–1906.— NEW YORK ZOOLOGICAL SOCIETY, bull. 27.— SELLING MAGAZINE, vol. 3, no. 5.— TECHINAL WORLD MAGAZINE, April.— UNITED STATES DEPARTMENT OF AGRICULTURE, Farmers' Bulletin 305; Production of Lumber, Laths and Shingles, by States and Species, 1906, 1905, 1904; Report on Sanitary Milk Production.

(No. 490 was issued November 2, 1907)

DARWINISM TODAY

By **Prof. Vernon L. Kellogg**, the author of "American Insects," etc. 395 pp. and index. 8vo. $2.00 net, by mail $2.15.

A simple and concise discussion for the educated layman of present-day scientific criticism of the Darwinian selection theories, together with concise accounts of the other more important proposed auxiliary and alternative theories of species-forming. With special notes and exact references to original sources.

PRESIDENT DAVID STARR JORDON in *The Dial*—"Its value cannot be overestimated. A book the student must have at hand at all times, and it takes the place of a whole library. No other writer has attempted to gather together the scattered literature of this vast subject, and none has subjected this literature to such uniformly trenchant and uniformly kindly criticism. An investigator of the first rank, and master of a clear and forceful literary style."

AMERICAN NATURE SERIES

Readable books of high authority

VOLUMES ALREADY PUBLISHED

C. W. Beebe's *The Bird:* Its Form and Function. $3.50 net. **V. L. Kellogg's** *American Insects.* $5.00 net. **C. E. Water's** *Ferns.* $3.00 net. **Dr. Curtis'** *Nature and Health.* $1.25 net.

VOLUMES IN PRESS

N. L. Britton's *North American Trees.* 1 vol. **D. S. Jordan's** *Fishes.* 1 vol.

Complete prospectus and detailed information on request.

HENRY HOLT AND COMPANY 29 W. 23D ST., NEW YORK

Recent Scientific Publications

HIGGINS' Lessons in Physics.

CONN'S Bacteria, Yeasts, and Molds in the Home.

YOUNG'S Manual of Astronomy.

BERGEN'S Botany Note-book.

BERGEN'S Elements of Botany. Revised Edition now ready.

MEIER'S Herbarium and Plant Description.
With Directions for Collecting, Pressing and Mounting Specimens.

MCGREGORY'S Manual of Quantitative Chemical Analysis.

MILLIKAN'S Mechanics, Molecular Physics, and Heat.

MILLER'S Laboratory Physics.

GINN & COMPANY PUBLISH LEADING TEXT-BOOKS IN ALL DEPARTMENTS OF SCIENCE. CORRESPONDENCE WILL RECEIVE PROMPT ATTENTION.

GINN & COMPANY Publishers

BOSTON. NEW YORK. CHICAGO. LONDON.

ALONE IN ITS FIELD

THE LIVING AGE

is the only American Magazine exclusively devoted to the reprinting, without abridgment, of the most important and interesting articles from the best English periodicals.

Published weekly, it is able to present this material while the topics considered are still fresh in the public mind.

With the whole range of English periodical literature to select from, it is able to present more important articles by well-known and brilliant writers than any other single magazine. It publishes

The Best Fiction **The Best Essays**

The Best Literary Criticism

The Best Travel Articles

The Ablest Discussions of Public Affairs

The single numbers are light and easy to hold, and the reading matter is not smothered in advertising. The numbers for a year contain as much as two of the four-dollar magazines.

The LIVING AGE has been published every Saturday without missing an issue for more than 63 years, and was never more indispensable than now to intelligent readers.

New subscribers for 1908 will receive free the remaining numbers of 1907 from the date on which their subscriptions reach the publishers. Specimen copy free.

Terms: $6.00 a year

Three Months' Trial Subscription, $1.00

THE LIVING AGE COMPANY

6 Beacon Street, Boston, Mass.

VOL. XLI, NO. 492 DECEMBER, 1907

THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

			Page
I.	Preliminary Notes on Some American Chalicotheres	O. A. PETERSON	733
II.	Observations on the Natural History of *Polyodon spathula*	CHARLES F. STOCKARD	753
III.	Fowler's "Heterognathous Fishes" with a Note on the Stethaprioninae	C. H. EIGENMANN	767
IV.	Pink Insect Mutants	WILLIAM M. WHEELER	773
V.	Notes and Literature: *General Biology;* The theory of mimicry.—The inheritance of disease.—Malaria in ancient Greece and Rome.—The distribution of European animals.—The dancing mouse. *Zoology;* Ichthyological notes.—Notes on the structure of insects.—British rhizopods. *Botany;* Recent studies on gymnosperms.—Xerophily of the gymnosperms.—Notes on the problem of adaptation.—Plant cultivation in art and education.—Lobed terminal leaflets in the rose.		781
VI.	Publications Received		816
VII.	Index to Volume XLI		i

BOSTON, U. S. A.
GINN & COMPANY, PUBLISHERS
29 BEACON STREET

New York
70 Fifth Avenue

Chicago
378-388 Wabash Avenue

London, W. C.
9 St. Martin's Street

Entered at the Post-Office, Boston, Mass., as Second-Class Mail Matter

NOTICE TO SUBSCRIBERS AND EXCHANGES.

The American Naturalist now completes its 41st volume. With the development of the natural sciences in this country, in which it has had an important part, many technical journals have appeared; but these have not deprived the *Naturalist* of its special field. Although dispensing with its early subtitle — A Popular Illustrated Magazine of Natural History — it has always aimed to present in readable form an account of the progress of natural history, together with original articles on such animals, plants, and geological formations as are of general interest.

In accomplishing this without the usual endowment or support of any scientific society, the journal has depended upon its owners and the public for financial support, and upon the unpaid work of editors and contributors for its success.

Messrs. Ginn & Company have decided to discontinue as publishers with the completion of this, their tenth volume. It is thought that to justify the work now being expended upon the journal, it should have a wider circulation and more generous support. The means of accomplishing this are being discussed, and the owners will be glad to receive practical suggestions from those interested. *Exchanges should be discontinued until further notice*, and subscriptions should not be paid until new plans have been adopted. Meanwhile all communications regarding *The American Naturalist* should be addressed to

FREDERIC T. LEWIS, *Editor*,
Harvard Medical School, Boston, Mass.

THE

AMERICAN NATURALIST

VOL. XLI *December, 1907* No. 492

PRELIMINARY NOTES ON SOME AMERICAN CHALICOTHERES[1]

O. A. PETERSON

COMPARATIVELY little is known of the American forms of the Chalicotherioidea;— an extinct family of mammals. Professors Marsh,[2] Cope,[3] Scott,[4] and Osborn[5] have from time to time published brief accounts of the few fragments available, but nothing comprehensive on the osteological structure of these unique animals has been accessible in America until quite recently.

A short time ago Dr. W. J. Holland, Director of the Carnegie Museum, gave the writer permission to submit to the Seventh International Zoological Congress some brief notes on the splendidly preserved remains of *Moropus elatus* Marsh which were secured by the Carnegie Museum from the Agate Spring Fossil Quarry in Sioux County, Nebraska.

This important fossil quarry has yielded much material which is now being prepared for study and publication. The quarry is located in the valley of the Niobrara River in the Lower Harrison horizon, and was evidently the bed of a stream, or perhaps the shore of a small lake, during a portion of the Miocene time. The bones were imbedded in a comparatively thin stratum of soft sandstone which was quarried out in large blocks. These were properly

[1]Read before the Seventh International Zoological Congress, Boston, Mass., August 21st, 1907.

[2] Am. Jour. Science, Vol. XIV, pp. 249–251, 1877.

[3] American Naturalist, Vol. XXIII, pp. 149–151, 1889.

[4] American Naturalist, Vol. XXVII, pp. 659–662, 1893.

[5] Bull. Mus. Comp. Zool., Vol. XX, pp. 99–100, 1890.

labeled with reference to their position in the quarry, in order to trace the different skeletal remains which may continue from one block to another. In working out this material, we find that there are parts of skeletons which are articulated and associated.

As there has been doubt among palaeontologists regarding Professor Marsh's genus Moropus, I decided to present the figures of some casts (Figs. 1–11). These were made, by permission of Professor Schuchert, from the types which were described as bones of edentates by Marsh. By permission of the Authorities of Yale Museum, these types are here illustrated for the first time, and they quite correctly represent the specimens. With the types are associated such specimens of Moropus from the Agate Spring Quarry (Figs. 12–20) as will at once show the characters which are identical.

EXPLANATION OF FIGURES 1–20

All figures ¼ natural size

Type of *Moropus distans* Marsh. From the John Day Formation, Oregon.

FIG. 1.— Dorsal view of first and portion of second co-ossified phalanges.
FIG. 2.— Proximal articular view of the cuboid.
FIG. 3.— Dorsal view of a second phalanx.
FIG. 4.— Plantar view of the same phalanx.

Type of *Moropus senex* Marsh. From the John Day Formation, Oregon.

FIG. 5. —Dorsal view of the first and portion of second co-ossified phalanges.

Type of *Moropus elatus* Marsh. From the Miocene of Nebraska.

FIG. 6.— Dorsal view of distal end of second metacarpal.
FIG. 7.— Tuberosity of calcaneum.
FIG. 8.— Dorsal view of metatarsals II and III.
FIG. 9.— Dorsal view of co-ossified first and second phalanges.
FIG. 10.— Dorsal view of patella.
FIG. 11. — Dorsal view showing the proximal end of a first phalanx.

Material of *Moropus elatus* Marsh, from the Agate Spring Fossil Quarry. Miocene of Nebraska.

FIG. 12.— Dorsal view of a second phalanx.
FIG. 13.— Dorsal view of patella.
FIG. 14.— Dorsal view of second metacarpal.
FIG. 15.— Proximal articular view of the cuboid.
FIG. 16.— An oblique view of the astragalus.
FIG. 17. — Dorsal view of co-ossified first and second phalanges.
FIG. 18.— Dorsal view of a first phalanx.
FIG. 19.— Front view of calcaneum.
FIG. 20.— Dorsal view of metatarsals II and III.

1

2

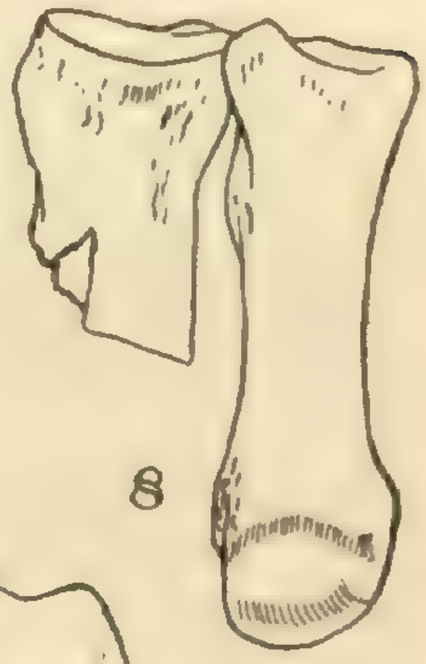
3

4

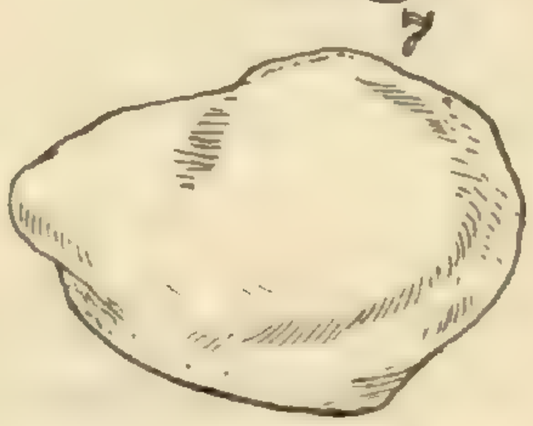
5

6

7

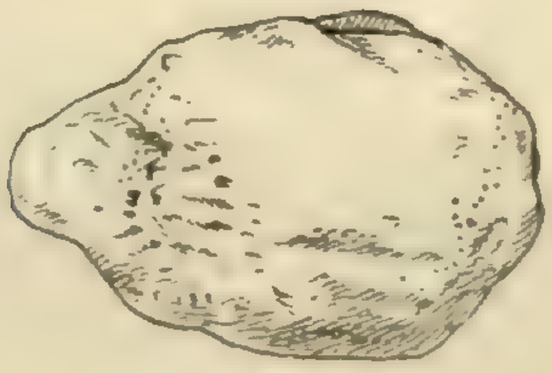

8

9

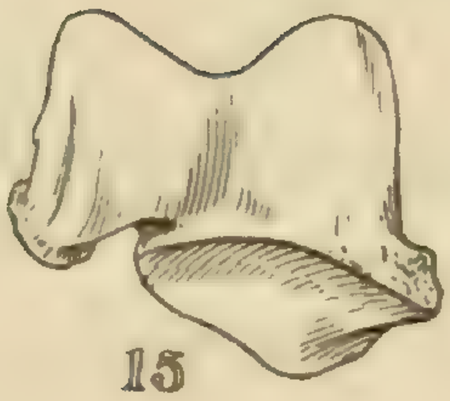

10

11

12


13

14


15

16

17

18

19

20

FIGURES 1–20.

The skeletal structure of Moropus is a unique combination of characters. The phalanges are highly modified, terminating in cleft ungues which were, no doubt, covered by heavy claws; otherwise the skeleton is distinctively of an ungulate type, most closely resembling the Perissodactyla. The fore limbs are longer than the hind limbs; they, together with the clawed feet, must have given to the animal a very peculiar appearance. Some species are as large as an African rhinoceros, or even larger. In the *American Naturalist*, March 1889, p. 151, Professor Cope established a separate order (Ancylopoda) for these different forms, which in the Miocene time extended over Europe, Asia, and America. After a study of the recently discovered remains, which include nearly all parts of the skeleton, the present writer would place Moropus as a distinct genus, in the Chalicotherioidea which, he is inclined to believe, should be considered as an aberrant superfamily of the Perissodactyla, as it was provisionally regarded by Professor Osborn[1] in a recent publication.

At this point it is thought best to give a short description of a few characteristic features in the osteology of the skeleton of Moropus as we know it from the material in the Carnegie Museum at Pittsburgh.

The Skull

No. 1707 Carnegie Museum Catalogue of Vertebrate Fossils.

The skull, on which these brief notes are based, was found in the Agate Spring Fossil Quarry by Mr. W. H. Utterback. It is that of a young individual, which, when found, was disarticulated. We have not, as yet, found a perfect skull of Moropus,[2] but aside from this our material is quite complete. The parts, associated in this skull, but which may not belong to the same individual, are the occipital condyle, the basioccipital (No. 1707 A), and the lower

[1] The Extinct Rhinoceroses. Memoirs of the American Museum of Natural History, Vol. I, Part III, p. 79, 1898.

[2] Professor Barbour of the Nebraska State University, Lincoln, Neb., was fortunate in securing a fairly good skull of Moropus from the same stratum on an adjoining hill.

jaws (No. 1711). The latter parts are here inserted (Fig. 21) in order to give a better idea of the cranium. Since no foot bones were found in connection with these skulls, a positive identification of the species as *elatus* Marsh can not be made.

The skull of Moropus, as a whole, is of the long and narrow type (Figs. 22 and 23) and is in a general way similar to that of Macrotherium of Europe.[1] In this young specimen from Nebraska there is no sagittal crest. The braincase is sub-ovate in form and of fairly large size. The parietal is present on one side and is of

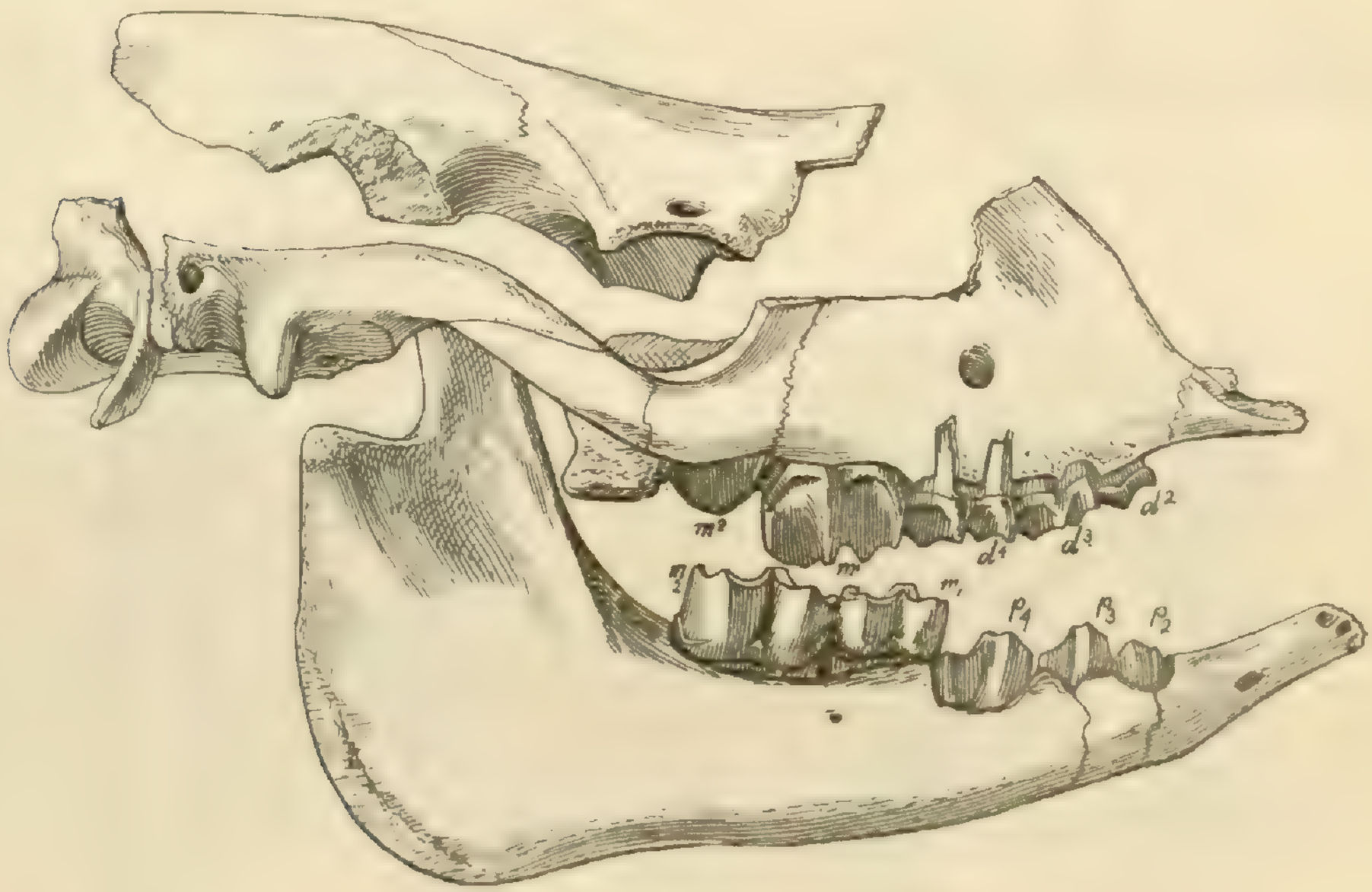


FIG. 21. — *Moropus elatus?* Marsh. ¼ natural size. Side view of the skull of a young individual, No. 1707; side view of the lower jaw of a young individual, No. 1711.

considerable antero-posterior diameter. Superiorly the bone is very gently convex from before backward, and the two parietals together meet the frontals in a broadly open U-shaped outline. The frontal is quite broad over the orbit as in Meniscotherium from the lower Wasatch, and the orbital border is heavy and somewhat overhanging with a large foramen near the margin. This is well shown in the illustrations (Figs. 21 and 22). The supra-temporal ridge is very faint; this may be due to the immaturity of

[1] See Professor Depèret's Memoir "Faune de Mammifères Miocenes de la Greve-St. Alban"; Arch. Muse. d'Hist. Nat. d'Lyon V, Pl. II., 1892.

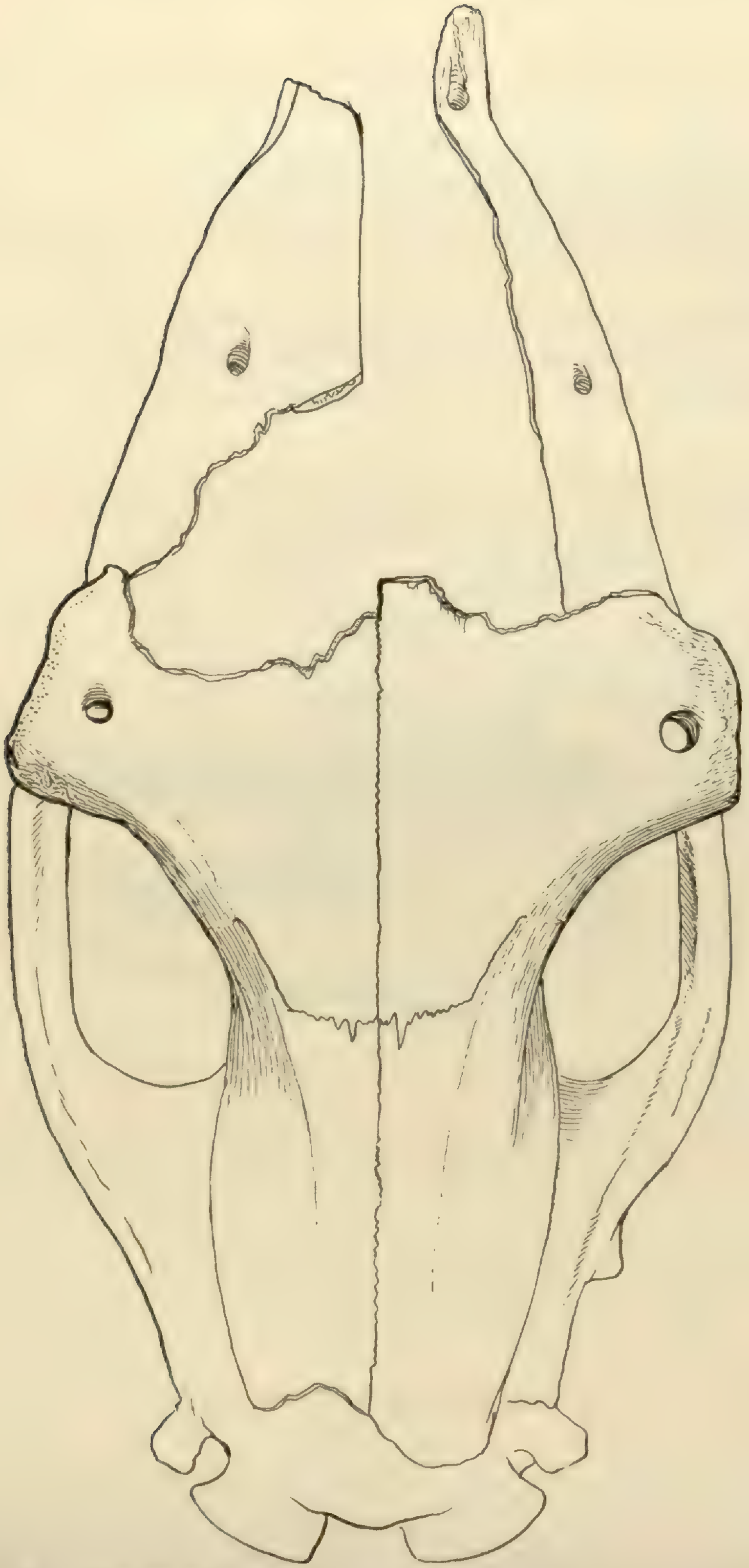


FIG. 22. — *Moropus elatus ?* Marsh. ½ natural size. Top view of the skull of a young individual, No. 1707.

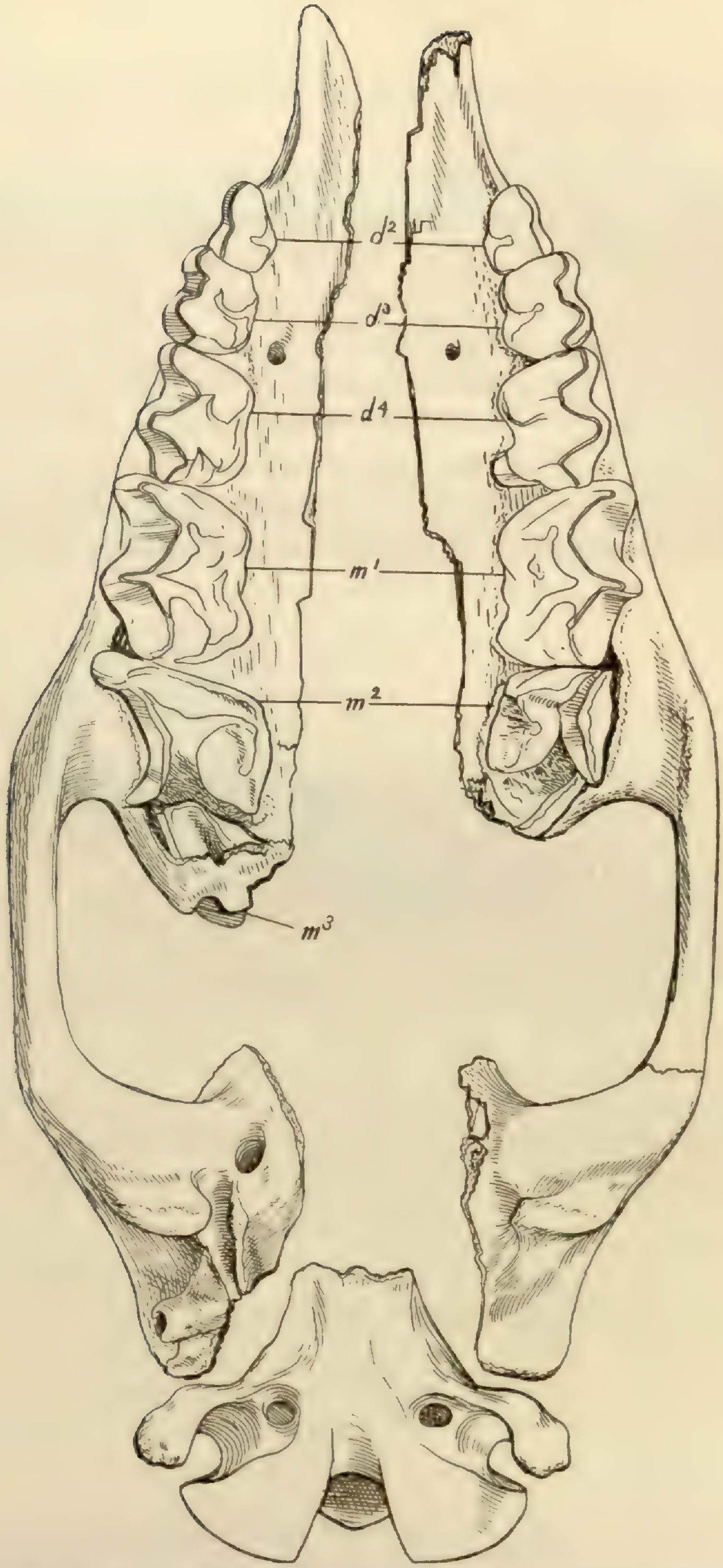


FIG. 23. — *Moropus elatus ?* Marsh. ½ natural size. Palate view of the skull of a young individual, No. 1707.

the specimen, but it continues from the inion to the orbital border. The orbit is located well forward on the skull and is open posteriorly in a similar manner to that of the known European forms. The maxillary bone is high and the maxillo-premaxillary suture ascends rapidly. The premaxillary bone of Moropus is not known, but I judge that it attained a considerable length and was perhaps edentulous or retained small incisors.[1] The infra-orbital foramen is large and is placed above D^4. The jugal is small with a delicate zygomatic process. The zygomatic process of the squamosal is equally small so that the arch is rather more delicate than that represented in the European genus. The glenoid process is of fairly large size and the space between the latter process and

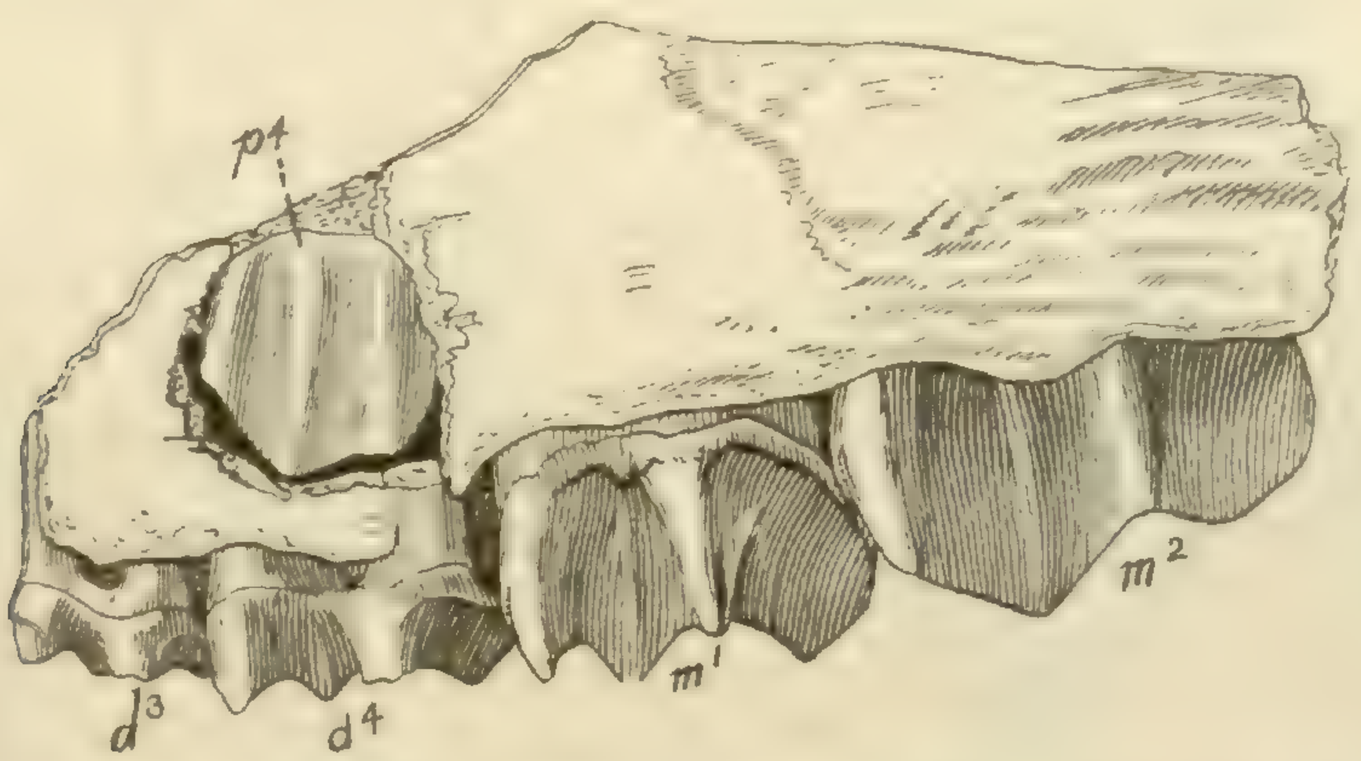


FIG. 24. — *Moropus elatus?* Marsh. ½ natural size. Side view of maxilla of a young individual, No. 1709, showing p^4 in an unerupted stage.

the paroccipital is occupied by the external ear and the mastoid in much the same way as in the recent horse. The external auditory meatus is of fairly large size and is directed outward and very slightly upward, not unlike that in Equus. Whether or not there was a tympanic bulla cannot be determined from the material at hand. The occipital condyle is large and there is a slight accessory facet on the basioccipital. The condylar foramen is of large size and is situated immediately back of the paroccipital process at its internal angle. The latter process is much elongated and suggests that of the recent horse. In fact a number of osteological features of Moropus suggest characters in the equine family of the Perissodactyla.

[1] Lower jaws of adults with incisors in place always show wear on the median pair, while the lateral teeth are almost entirely unworn.

The molar-premolar series of Moropus has a general similarity to that of the Titanotheres, but a brief comparison of the more important differences is thought to be of interest in this connection. The external walls of the upper premolars of Titanotherium are excavated, forming a transverse median valley on the grinding face of the teeth, while in Moropus the walls are highest in the middle, and this portion of the tooth is not divided by a transverse valley. The internal cusps of all the upper premolars in Titanotherium have a tendency to become divided so as to form a larger anterior and a smaller posterior tubercle. In Moropus the single tubercle is crescentic, especially on P^4. On the molars of Titanotherium there are two distinct internal tubercles, while in

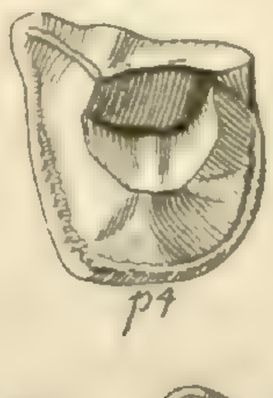


FIG. 25. — *Moropus elatus?* Marsh. ½ natural size. Crown view of the same specimen as Fig. 24.

Moropus there is only one tubercle and a transverse cutting lobe on the posterior internal angle of the tooth. This transverse lobe which unites with the external part of the tooth has apparently taken the place of the posterior internal tubercle (hypocone) of Titanotherium and is similar to that of Meniscotherium as was pointed out by Professor Osborn in comparing the latter with the known genera of the Chalicotherioidea.[1] The upper molars in Moropus are relatively longer and narrower than in the Titanotheridae; they are also longer and narrower than the upper molars of the best known forms of Chalicotherioidea in Europe and Asia.[2]

[1] American Naturalist, Vol. XXVII., p. 127, February, 1893.

[2] On Plate III., figs. 3, 4, and 5 in Depèret's Memoir, l. c., are figures of upper molars which more nearly agree in diameter with those of Moropus.

The close similarity of the lower molar-premolar series of Chalicotherioidea to that of Titanotherium and Palaeosyops is well known. As in the European forms, the present genus has also the premolars reduced to three teeth in both upper and lower jaws, while in the Titanotheridae there are four. P_2 in Moropus is quite simple in structure, while P_3 is more nearly like P_2 in Titanotherium. The internal tubercle of P_4 in Moropus is somewhat heavier than that in Titanotherium, otherwise the tooth suggests that of the latter genus. M_1 and M_2 in Moropus are similar to those in Titanotherium. M_3 in the latter genus has a prominent posterior heel which is lacking in Moropus. This third lobe of M_3 is also lacking in the Wasatch genus Meniscotherium.

The deciduous upper molars (No. 1709) in Moropus are more nearly molariform than are the permanent premolar series.[1] Deciduous M^4 (d^4 and dm^4 in Figs. 24 and 25 respectively) may very easily be taken for the permanent M^1, if extreme care is not exercised in the study of the dentition. The permanent P^4 cuts the alveolar border shortly after permanent M^2 is entirely erupted.

Measurements of the Skull

	mm.
Diameter of skull, from external auditory meatus to extreme anterior point of maxillary,	305
Diameter of skull, from external auditory meatus to anterior border of the orbit,	160
Diameter of skull, from anterior border of the orbit to extreme anterior point of the maxillary,	150
Transverse diameter of the frontals over the orbits,	160

Vertebral Column

No. 1604, Carnegie Mus. Cat. Vert. Foss.

The vertebral formula of Moropus is for the most part based on a skeleton, the bones of which were found disarticulated, but

[1] Hatcher has pointed out this same characteristic feature in Titanotherium, Annals Carnegie Museum, Vol. I, pp. 259–260, 1901.

quite close together, in the Agate Spring Fossil Quarry. As the vertebrae are found to fit one another in a quite perfect manner, there is very little doubt that the cervicals and the dorsals are, excepting the eighth and eleventh dorsals which are evidently lost, correctly represented by this specimen. We found seven cervicals, thirteen dorsals, and three anterior lumbars belonging to the same individual. The cervical and dorsal regions are apparently quite complete, while three lumbars are lacking, but judging from other individuals found in the quarry the complete number in the lumbar series was six. There was no sacrum with this individual, but we know that there are four sacral vertebrae. The caudal region is not fully known, but I judge that it attained a length about equal to that in the rhinoceroses generally.

The Cervical Vertebrae.— For an animal with a comparatively small head, the cervical vertebrae of Moropus are quite robust. The general structure of the cervical region suggests that of the recent horse. With the exception of the greater angularity of the transverse process, the different position of the arterial canal and the open atlanteal notch, the atlas might be taken for that of a large specimen of *Equus caballus*. The axis is still more suggestive of the horse, but the inferior keel is larger and the neural spine higher,[1] more overhanging in front, and somewhat more robust. The articulation for the atlas has the same spout-shaped extension anteriorly, but with the median protuberance relatively much enlarged, forming a curious knob which doubtless represents the primitive odontoid process. With the exception of the more produced condition of the centra posteriorly, the more broadly developed hypapophysial keels inferiorly, the higher neural spines, the relatively heavier neural arches, and the larger zygapophysial faces, the general make-up of the cervicals back of the axis in Moropus is similar to that in Equus. There is no vertebrarterial canal in the seventh cervical. That the animal could easily reach the ground with his head is very evident from similarities of the cervical articulations to those of *Equus caballus*.

[1] The axis of Macrotherium of Europe is described and figured by Professor Depèret and presents the same general characters as that in the American species. The neural spine of the former is relatively higher than that in the latter species.

The Dorsal Vertebrae. — Although the number of the dorsal vertebrae in Moropus is less (there are thirteen present and two — the eighth and eleventh dorsals — lost in the specimen under consideration) they are perhaps more suggestive of those of Aceratheria or Metamynodon from the Oligocene than those of the horse. The first dorsal in Moropus has a relatively longer neural spine than that in the horse, and in this respect it resembles more nearly some of the more primitive perissodactyls. The seventh, ninth, and tenth dorsal vertebrae in No. 1604 have complete neural spines. It is seen that the neural spines of the latter vertebrae are relatively shorter and have a more backward slope than in the horse. The thirteenth and fourteenth dorsals have wide neural spines, which are constricted antero-posteriorly at their bases. In these vertebrae there are strong metapophyses. The fifteenth dorsal vertebra in Moropus is quite characteristic and is different from all preceding vertebrae. The posterior zygapophyses have already become convex in the same manner as in the lumbar region.

The transverse process is pierced at the base by a large foramen and is further characterized by having a superior and an inferior division. The superior division of the transverse process is the larger of the two and is directed outward, while the smaller inferior division has a downward and backward direction. Between the two divisions there is a deeply emarginated area, which is converted into a thin bony bridge bounding the foramen referred to above. On this and the succeeding vertebra (the first lumbar) the metapophyses are the heaviest and they rapidly decrease in size on the succeeding lumbars, while on the dorsals there is still a very small metapophysial protuberance left on the seventh vertebra.

Only the first three lumbar vertebrae are present in No. 1604, the specimen under consideration, but from other material found in the quarry it is quite certain that the complete series is six. The three lumbars present are very robust, and possess broad neural spines which are enlarged and rugose at the superior end. The zygapophyses are simply convex and concave with no additional superior articular faces. The transverse processes are only moderately developed.

The Sacrum. — The sacrum (No. 1706) is composed of four

vertebrae well co-ossified, with high and backwardly sloping neural spines which are all co-ossified and increase in robustness from before backward. The neurapophysis of the first sacral is very heavy and supports the greatest weight of the ilium, though the succeeding three sacrals share in the support as there is a rugose attachment for the ilium throughout the entire length of the sides of the sacrum.

A number of caudals of considerable length, found in the quarry, may belong to Moropus but this is not fully determined at present.

In No. 1604, Car. Mus. Cat. Vert. Foss., the best preserved skeleton of Moropus, there are present fifteen ribs of the right and fourteen of the left side; the first rib of the left side is lost. The ribs are of moderate length, but robust, and the anterior ones are expanded at the lower ends, indicating a heavy sternal attachment.

Limbs

Nos. 1604; 1706; 1710; Carnegie Mus. Cat. Vert. Foss.

The structure of the fore and hind limbs of Moropus was briefly described in a former paper,[1] and I wish here only to call attention to a few of the more important features which are shown in the splendidly preserved material in the Carnegie Museum.

The Fore Limb.— The scapula of Moropus is quite large. It is plainly of a perissodactyl type, and resembles most closely that of *Aceratherium tridactylum* Osborn. As in the latter genus the spine is prominent and overhangs the post-scapular fossa in a similar manner. The humerus, radius, and ulna of Moropus, as a whole, are quite like these parts in the European genera.[2] The humerus of Moropus has a heavy deltoid ridge, which extends well down on the shaft. The greater tuberosity is also quite robust and the bicipital groove is single and moderately deep, but quite broad. The distal end is much expanded transversely and suggests that of

[1] Annals Carnegie Museum, Vol. IV, No. I, pp. 60–61, 1906.

[2] In *Macrotherium grande* the fore limb is relatively longer than in Moropus according to the figures and description of Professor Depèret, "La Faune de Mammifères de la Greve-St. Alban" Pl. IV, Figs. 2 and 9.

Phenacodus from the Wasatch. The trochlea is broad with well rounded articular surfaces for the radius and ulna. The anconeal fossa is quite deep and broad, but low. In this specimen (No. 1604) the radius and ulna are entirely co-ossified. On the radius the external articular facet for the humerus is considerably larger than the internal, while on the ulna the internal articulation is very extensive. On a direct front view the head of the radius lies in front of the ulna, but immediately below the head on the external side, the shaft of the ulna again appears. The olecranon of the

A B

Fig. 26. — *Moropus elatus* Marsh. About $\frac{1}{8}$ natural size. A, the left fore foot of skeleton No. 1604. B, the left hind foot, No. 1710, which belongs with another skeleton.

ulna is rather truncated. The distal end of the radius and ulna together have a transversely broad aspect; the carpal articulation is characteristically plain without the prominent border which separates the scaphoid and lunar facets in other Perissodactyla. The articular surface for the cuneiform on the ulna project only very slightly below the radius and form, with the lunar articulation on the radius, a continuous and gently curved surface. The suture

between the radius and ulna is, however, well indicated on the distal articulation of the bone.

The Manus.— The manus of Moropus has four digits, three of which are functional and one (the fifth) rudimentary. This rudimentary fifth metacarpal is not supported by the unciform, but articulates with the fourth metacarpal by fairly well formed facets. Mc.V [1] in No. 1700, Car. Mus. Cat. Vert. Foss., is much slenderer and attains only three-fourths the length of mc. IV. The distal trochlea of mc. V., in No. 1700 is quite imperfect and the digit had perhaps only one phalanx. The trapezium is present and articulates with mc. II, the trapezoid, and the scaphoid, but there is no indication of a first digit. The heavy protuberance on the scaphoid of Moropus which reaches over the trapezoid and articulates with the magnum may be represented by the centrale in Meniscotherium.[2] The magnum has a heavy protuberance on the anterior face which extends dorsally and forms, on the distal face, a rough articular surface for the proximal end of mc. II; on the palmar face is a short but heavy hook, and the total vertical diameter of the bone is much greater than is apparent on a direct front view of the manus. The second metacarpal, though shorter than the third and fourth, is the heaviest in the series. The third metacarpal is the longest, consequently the second and third digits in the manus of Moropus supported the greatest weight; therefore the manus is more nearly mesaxonic than was anticipated. It is different from the European genus from Sansan in which mc. IV is the longest.

In the manus of Moropus, the first and second phalanges of the second digit are co-ossified, an important character which Professor Marsh luckily discovered in three different individuals. This now proves to be of perhaps a family importance.[3] The ungual phalanx of the second digit is much larger than those on the third

[1] In No. 1604 the fifth metacarpal is wanting, but the articular facets of mc. IV plainly indicate its presence.

[2] Amer. Jour. Science, Vol. XLIII. p. 447, 1892. (*Hyracops socialis* Marsh.)

[3] From Cope's statement in the American Naturalist, March, 1889, Vol. XXIII. p. 153, I infer that Lydekker has said that "Ancylotherium" Gaudry has the first and second phalanx co-ossified. Good casts of the latter genus are exhibited in the American Museum of Natural History which confirm this statement.

and fourth, and is more conspicuous than that of the European form from Sansan. In Moropus as in "Ancylotherium" this large ungual has a comparatively limited dorsal flexure, as there is a shoulder near the dorsal border of the distal trochlea of this duplex bone and a corresponding buttress on the articulation of the terminal phalanx; thus furnishing additional strength in the use of this digit.

Hind Limb.— The pelvis (No. 1706) of Moropus may be regarded as long and narrow. In comparing it with that of Perissodactyla generally it is relatively longer in the region back of the acetabulum, which feature is artiodactyl rather than perissodactyl. Altogether, the pelvis of Moropus most nearly agrees with that of *Aceratherium tridactylum*. As in the latter genus, the neck of the ilium is long with a rapid expansion near the supra-iliac border, but this border is less emarginated than in Aceratherium. In Moropus the acetabulum is deep, and the pit for the round ligament is of large size and is confined to the region back of the median line. The obturator foramen is ovate in outline and of medium large size. The pubic symphysis is quite strong anteriorly, but in No. 1706, Carnegie Museum Cat. Vert., Foss., the ischium diverges outwardly more than is usual in other specimens.[1] As stated elsewhere, the femur has a strong third trochanter, which is located above the middle of the shaft. The bone as a whole resembles that of Titanotherium, but is relatively heavier and shorter. The tibia is short and heavy; it is about four-fifths the length of the femur. The articular facets for the femur are divided by a prominent spine, the cnemial keel is heavy and extends well down on the shaft, and the distal trochlea is characteristically rhinocerotic. The fibula is complete, but its shaft is comparatively delicate and has an even curvature from above downward so that it lies close to the shaft of the tibia throughout; the distal end extends below the external articular facet of the tibia and articulates with the astragalus, but does not always touch the calcaneum.[2]

[1] The peduncle of the pubis in this specimen was badly crushed on one side and partly lost on the opposite side which may, in part at least, account for this difference.

[2] Some specimens have a minute articular facet for the fibula on the calcaneum.

The Pes.—In a general way the tarsus (No. 1710) in Moropus is much like that of the Rhinocerotidae. There are, however, many differences viz: the navicular is supported entirely by the astragalus and the cuboid by the calcaneum as in Meniscotherium. The trochlea of the astragalus is somewhat more deeply grooved, the internal and external condyles are more even in size and the external condyle is not interrupted as in Titanotherium, but continues below the articular facet for the navicular. The pes is tridactyl; there is no indication of lateral digits. The second metatarsal is shorter and also somewhat lighter than the third and fourth which are of equal size. The articulation for the proximal phalanx is confined almost entirely to the dorsal face of the bone, while on the plantar face are deep, broad grooves, which are divided by heavy keels. The sesamoids are very heavy and in some cases they are co-ossified, forming a broad open groove for the tendons. As in the fore foot the claw-bearing ungulae are deeply cleft, but of more nearly equal size.

From the study of the foot and limb structure of Moropus it is very evident that the animal was digitigrade. Professor Osborn has called attention to the fact that the European forms were "almost certainly sub-digitigrade."[1]

The remains above described (No. 1604) belong to an individual very nearly the size of *Chalicotherium goldfussi* of Europe, or the size of a small specimen of Titanotherium from the American Oligocene. Smaller remains are more common in the quarry, indicating two or more species, or a great range of individual variation. This question will be taken up in a later publication. There are perhaps twenty individuals of Moropus represented in the collection of the Carnegie Museum, which were secured in the Agate Spring Fossil Quarry.

Discussion of Affinity and Phylogeny

In *Chalicotherium goldfussi* Kaup, P^4 has the internal face of the ectoloph W-shaped and the internal tubercle of a different form and more distinctly separated than in the American genus. In the

[1] American Naturalist, Vol. XXVII, pp. 118–119, 1893.

latter, the ectoloph is simpler, and the internal tubercle is crescentic, as in the Artiodactyla, the posterior and anterior horns being firmly united with the ectoloph so as to form, of the median valley, a deep, but rapidly sloping pit. This is best seen in an unworn tooth. The upper molars, especially M^2 and M^3, in Moropus are relatively longer and narrower than in *Chalicotherium goldfussi*. The teeth in the latter species appear to have more nearly the same proportionate diameter as in the Asiatic forms *C. siense* and *C. sivalense*.[1] The more important differences between *C. sivalense* and *C. siense* as pointed out in Professor Owen's paper (l. c. pp. 431–432) are as follows: "the anterior part of the interval between the post-external (b) [b = reference to the illustrations in Owen's paper] and the postinternal (d) lobes is not closed by a ridge descending from the summit of the postexternal lobe as in *Chalicotherium sivalense*: nor does the inner side of the antexternal lobe terminate in so ridge-like a way as in *Chalicotherium sivalense*." The condition of the post-external and post-internal lobes, as well as the "ridge-like" ant-external lobe of M^3 in Moropus agree more closely with Owen's statement of *C. sivalense*; and M_3 in Moropus is very nearly of the same size and of the same general character as that in *C. goldfussi*, but the relative diameter,[2] together with other less important differences of M^3 in the European and Asiatic forms, is entirely unlike those in Moropus.[3]

Phylogeny.—The best evidence at the present time points rather towards a European[4] than an American ancestry of Moropus.

[1] Quart. Jour. Geol. Society, London, Vol. XXVI, p. 431, 1870.

[2] For measurements of upper teeth of Moropus see Annals Carnegie Museum, Vol. IV, No. I, p. 63, 1906.

[3] *Chalicotherium* (*Ancylotherium*) *pentelici*, from Pikermi, Greece, has the upper molars longer than broad, and in some other respects most nearly agree with the American form.

[4] Schizotherium Gaudry of the European Oligocene is undoubtedly an ancestor of the family. And it is likely that some European Eocene form allied to the early perissodactyls will be found to be the true ancestor. Some characters of Palaeotherium are suggestive of the Chalicotherioidea.

NOTE: While at the International Zoological Congress in Boston, I discussed the phylogeny of Chalicotherioidea with Professor Depèret who kindly added the following note: "Le plus ancien type européen des Chalicotherioidea est le Pernatherium Gervais, du calcaire de St. Ouen près Paris: il est de l'étage Bartonien, c'est à dire, à peu près du Bridger supérieur (voir Journal de Zoologie.)"

Professor Osborn has pointed out Meniscotherium from the American Eocene (Wasatch) as a possible ancestor of the Chalicotherioidea.[1] It would seem that when better specimens of *Moropus distans* are found in the John Day formation, it will become necessary to separate, generically, *Moropus elatus* from *Moropus distans*. "*Chalicotherium bilobatum*" Cope from the Oligocene of the Swift Current Creek in Canada, if correctly identified, is of course a much earlier form than *Moropus elatus* from the Miocene of Nebraska. The remains which Professor Scott reports from Montana (Deep River) may perhaps represent a transitional form between *Chalicotherium bilobatum* and *Moropus elatus*. These appear to be the evidence which we have of the presence of the chalicotheres in the American Tertiary. The little known *Spenocoelus uintensis* Osborn from the Uinta beds[2] bears some resemblance to the Chalicotherioidea as was pointed out by Osborn (l. c. p. 102), but the specimen (the posterior portion of the skull) is too imperfect for accurate comparison. While Meniscotherium may not be a true ancestor of Moropus there are in the latter certain affinities[3] to the former which are of much importance and which point to the ancestral types of the stem of the Perissodactyla.

Conclusion

The conclusions drawn from the material studied may be summed up as follows: (1) That Moropus is, excepting its unguiculate feet, essentially a perissodactyl in structure. (2) That the laterally compressed and cleft condition of the terminal phalanges is quite distinct in some of the early Perissodactyla,[4] and that by adaptation through geological ages the unguals as well as other parts of Moropus were specially modified, and should not, in the mind of

[1] American Naturalist, February, 1893, pp. 118–133.

[2] Bull. American Museum of Natural History, Vol. VII, pp. 98–102, 1895.

[3] The absence of the 3rd lobe of M_3; the 3rd trochanter of the femur, and the navicular articulating, proximally, only by the astragalus and the cuboid by the calcaneum.

[4] It is well known that Euprotogonia and some species of Phenacodus have the terminal phalanges laterally compressed, intermediate between hoofs and claws. The early horses have cleft ungues.

the writer, be regarded as of ordinal importance. (3) That Moropus is generically separable from other known forms of the Chalicotherioidea.

The illustrations are from drawings made by Sidney Prentice and photographs made by A. S. Coggeshall.

Carnegie Museum
Pittsburgh, Pa., Aug. 2, 1907

OBSERVATIONS ON THE NATURAL HISTORY OF *POLYODON SPATHULA*

CHARLES R. STOCKARD

DURING the springs of 1904 and 1905 I visited the regions in which Polyodon attains its largest size and occurs in greatest abundance. I had been aware for several years of the existence of this fish in great numbers in the lakes bordering the lower Mississippi River. On mentioning this fact to Professor Bashford Dean, he suggested to me the desirability of visiting these lakes with the object of obtaining the eggs and developmental stages of this peculiar fish. My best thanks are due Professor Dean for this suggestion, and for placing at my disposal during both years the Dyckman Fund of the Zoological Department of Columbia University with which to defray the expenses of the trips.

Most vertebrate embryologists and particularly those familiar with the development of the ganoids will admit, I believe, that a knowledge of the development of Polyodon is greatly desired. The ganoids at present furnish an almost complete and one of the most instructive comparative embryological series. The series is incomplete, however, in that nothing is known of the development of either member of the order Selachostomi. This order comprises only two species, *Polyodon spathula* and *Psephurus gladius*. The former is found in the Mississippi River and its tributaries; the latter is known only in some of the rivers of China. Thus they have a decidedly discontinuous geographical distribution.

I spent from March first to April fifteenth, 1904, in Concordia and Catahoula Parishes of Louisiana, and from April first until May eighteenth, 1905, in Washington County, Mississippi, and on the White River in Arkansas. During this entire time efforts were made to obtain spawning Polyodon. Although unfortunately I failed to secure any of the embryonic stages, I succeeded, during the three months on the lakes and rivers where this fish is so abundant, in making many observations on its habits. The present paper contains a brief account of the behavior of the fish

during the spring and early summer seasons, and conveys some idea of the great fishing industry to which it has given rise within the past twelve years.

DESCRIPTION OF POLYODON

Polyodon in the lakes bordering the lower Mississippi River attains a much greater size than in the Ohio and upper Mississippi River region. Museum specimens and those obtained in the more northern parts of their range are rather small fishes. In the metropolis of their distribution, however, they often attain a length of almost six feet, the longest one observed by the writer being five feet and nine inches from the tip of the tail to the end of the snout. Their weight often exceeds one hundred pounds; one hundred and forty-two pounds was the maximum record in Lake Washington, Mississippi, where the fish were larger than in any other lake visited.

The shape of Polyodon is shown in the accompanying photograph, Fig. 1. Note the contrast between the slender shark-like form of the middle individual, which is a characteristic river-fish, and the heavily proportioned body of the lake-fish, on either side.

The color of these fishes during the spring differs only slightly from that at other seasons. The back and dorso-lateral portions are of a steel or slate-like hue while the ventral and ventro-lateral parts are a glistening milk-white. The fins of most mature individuals show a delicate tinge of salmon-pink, but in others the fin color partakes of the general slate-like appearance of the dorsal portions. The general color of several fishes that were obtained shortly after spawning was of a peculiar reddish tint, being several shades lighter than the normal slate color. In two "spent" individuals this color difference was detected as they swam in the water before being lifted from the seine. The anal region of these fishes showed a dark purplish-red color and their ovaries gave unmistakable evidence that spawning had occurred. No indication of sexual dimorphism could be detected, the males and females being indistinguishable in their color, size, and shape, and in the proportions of their external body appendages. A female with

her ovaries filled with eggs of the season was usually recognized by the distended condition of the abdomen and yet even this distinction was not always valid since the males when fat and in good con-

FIG. 1. — Three large specimens of Polyodon. The middle fish, from the river, is thin and slender, showing a torn fin and scars received while migrating. In contrast, the lake-fishes on either side are fat and well rounded, the one on the left showing an unusually distended abdomen although it is a male.

dition have so extensive a mass of adipose tissue about the testes that their abdomen is almost equally swollen. The fat about the testes of one male was found to weigh three and three-quarters pounds.

The larger females contain an enormous number of eggs. Sixteen pounds of roe was the heaviest single yield observed, but the maximum is no doubt greater; ten to twelve pounds was an average yield. The egg resembles that of Acipenser very closely in size and color. It is slightly oval in shape with the polar diameter longer and measuring about 2.7 mm.; the equatorial diameter is only about 2.2 mm. It is of a dark brown or blackish color. There is a considerable polar differentiation, the animal pole of the egg having a cap of lighter colored protoplasmic material with a rather distinct dark ring about its lower border. The denser deutoplasmic part of the egg is gradually located about its lower, vegetal pole.

Various measurements were made on a number of fish in the hope of discovering some sexual difference. While making such measurements a rather interesting ratio was found to exist between the length of the fish and that of the snout, as will be seen by referring to the accompanying table. In the table the individuals are arranged in the order of their lengths, the longest fish being at the top of the column. The entire length of the fish is expressed in inches in the first column and the length of the rostrum, from the anterior border of the eye to the tip of the snout, in the third column; by dividing the latter measurement by the former in any one case, the decimal given in the fifth column is obtained. The decimal, then, represents the fraction of the entire body length which is formed by the snout, and it is seen by comparing the data given for fifteen individuals selected at random, that the proportionate length of the snout decreases gradually and quite regularly as the fish increases in size. In other words a small fish, about two feet in length, has a snout one-third of the length of its body or eight inches long; and the large fishes, like the third and eighth individuals of the table, may have snouts less than one-fourth of their body lengths. Between these extremes one finds a regular gradation as is shown in the fifth column of the table.

Table I.

Length in inches	Sex	Length of rostrum	Weight	Proportion of rostrum length to body length	Remarks
69	♀	17.87	——	.258	Lake fish. 8 lbs. eggs.
67	♂	17.00	43 lbs.	.253	Lake-fish.
66	♀	15.75	41 "	.238	River-fish.
63	♂	16.50	62 "	.264	Lake-fish.
63	♀	15.75	90 "	.250	Lake-fish. 12 lbs. eggs.
62	♀	16.00	57 "	.258	Lake-fish.
60	♂	15.90	54 "	.266	Lake-fish.
59	♂	14.00	50 "	.237	Lake-fish.
53	♀	13.50	23 "	.254	River-fish.
51	♂	13.50	——	.265	Lake-fish.
49	♀	13.10	31 "	.267	Lake-fish.
44	♀	12.00	25 "	.272	Lake-fish.
36	♀	10.20	18 "	.283	Lake-fish.
30	♂	9.00	——	.300	Lake-fish.
24	♂	8.00	——	.333	Lake-fish.

By means of the above proportion one may calculate approximately the size of a fish from a small drawing. To test this I measured and calculated the proportion of length of rostrum to length of body in the Polyodon figured in Jordan and Evermann's Pl. XX, figs. 43 and 43a; the proportion found was .327 which according to the table would indicate that the specimen was about twenty-five or twenty-six inches long. Calculating from the inch line which accompanied the figure I found that the specimen was 27.2 inches in length, a very close agreement with my expectation.

From a few comparisons made between fishes living in the lakes and those in the river, it appears that the river fish have shorter and broader snouts in proportion to their entire body length than those living in Lake Washington.

Haunts and Habits of Polyldon

The lakes in which these fishes are found in great abundance are the old "cut off" lakes of the Mississippi River. These crescent or horse-shoe shaped bodies of water were formed from time to time as the course of the river changed. Some of them are at present almost completely separated from the river, being connected only by a long chain of bayous and lagoons, oftentimes

almost one hundred miles in length. Other such lakes still retain a direct connection with the river and are termed by the fishermen "river-lakes." In these there is a current which often becomes very strong during the spring freshets, when the water of the Mississippi River rises.

Lake Louis in Catahoula Parish, Louisiana, is a very old lake, being now only from one to three hundred yards in width and about six miles long. During the spring floods the Ouachita River sends a large volume of "backwater" into it, sometimes causing it to rise as much as twenty feet. In many places the lake is from forty to fifty feet deep. Polyodon exists in this lake in large numbers, but it is an undesirable place for seining and therefore offers poor facilities for the study of the fish. Lake Washington in Washington County, Mississippi, is by far the richest source of Polyodon that I have been able to locate. This lake is a beautiful body of water more than one mile across in several places, and about twelve miles long. It connects with the Mississippi through about seventy miles of smaller lakes and bayous. As many as one hundred and fifty barrels of Polyodon have been caught in this lake at one haul of the enormous seine described below.

Polyodon, like most large fish, frequents the deeper portions of these lakes and is rarely caught in the shallower parts. It is almost never found in lakes less than ten feet in depth. Usually it is caught in those parts of the lakes having soft muddy bottoms, the sections with hard sandy bottoms yielding no Polyodon when seined. This is due to the feeding habits of the fish. The main diet of Polyodon consists of small Crustacea, usually copepods. These are very probably obtained by stirring the muddy bottoms and gulping in the agitated material, which is then effectively strained by means of the long slender gill-rakers, so that only the small arthropods remain in the mouth to be swallowed. One may often scrape more than a double-hand-full of these Entomostraca from the mouth of a Polyodon freshly brought up by the seine. The copepods were often alive, with their egg strings still intact, and in good condition for preservation. Jordan and Evermann state that "They (Polyodon) feed chiefly on mud and minute organisms contained in it, stirring it up with the spatulate snout." One must surmise from the general structure of the mouth and

gill-rakers that they feed on minute organisms, but Jordan and Evermann are surely in error, so far as my observations on some four hundred stomachs go, in stating that they feed chiefly upon mud. No doubt some fine mud or silt is taken into the throat along with the food, but it appears to be well strained out, since scarcely any mud has been found in the many stomachs examined.

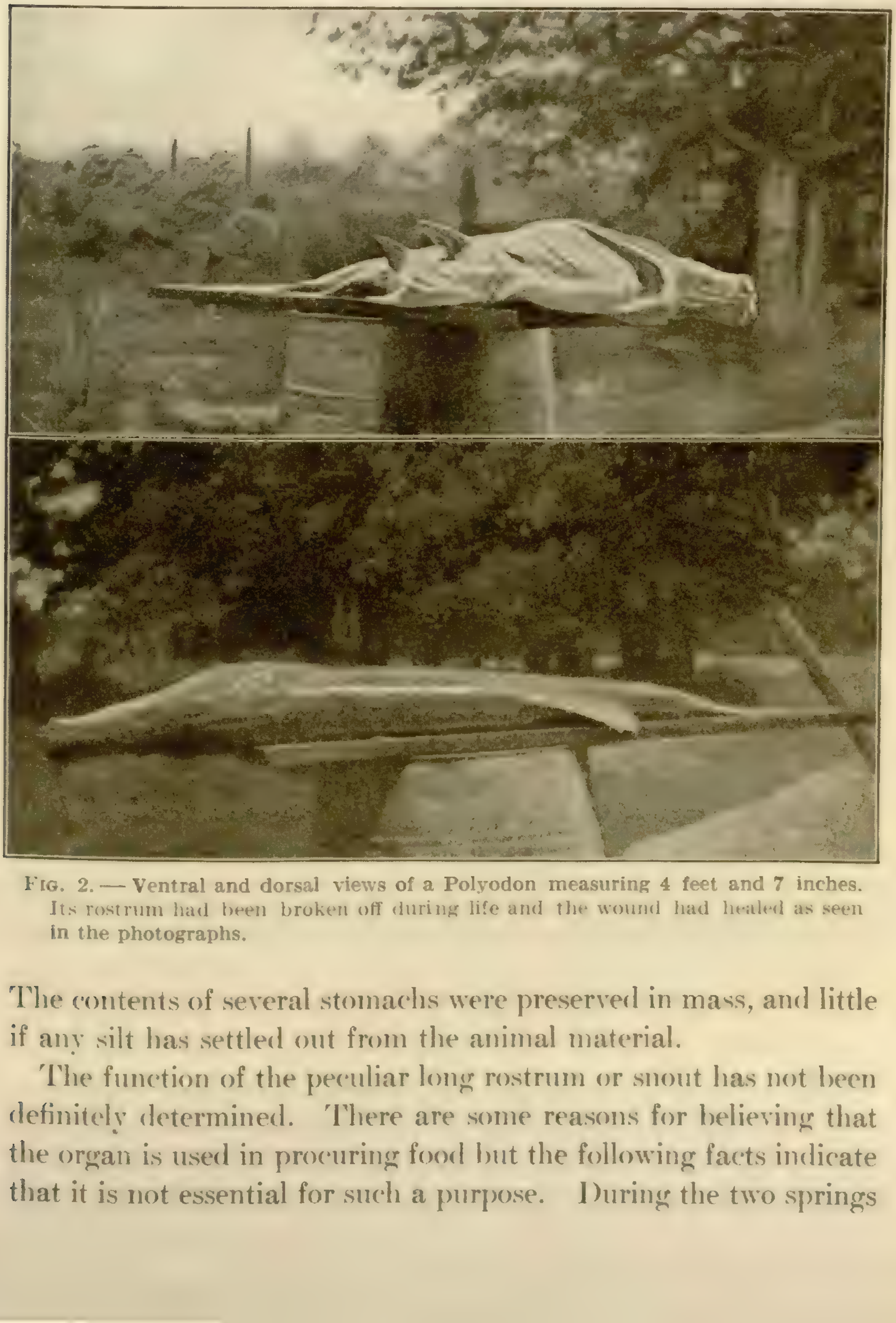


FIG. 2. — Ventral and dorsal views of a Polyodon measuring 4 feet and 7 inches. Its rostrum had been broken off during life and the wound had healed as seen in the photographs.

The contents of several stomachs were preserved in mass, and little if any silt has settled out from the animal material.

The function of the peculiar long rostrum or snout has not been definitely determined. There are some reasons for believing that the organ is used in procuring food but the following facts indicate that it is not essential for such a purpose. During the two springs

three specimens were found which had, through some mishap, been left with only stumps of their snouts. Fig. 2 shows a photograph of such a fish. In each case the fish was large, two being nearly four feet in length and the other measuring four feet and seven inches. In each the injured part of the snout was well healed, but no indication of regeneration of the organ was shown. It is evident from these individuals that this fish without the aid of its snout is capable of procuring food enough to maintain a large body. Moreover if the appendage was lost while they were yet small, they had succeeded in increasing in size without their "spatula with which to agitate the mud."

Fishermen state that large holes are often rooted out in the lake bottoms by the digging of Polyodon with its "paddle." In the bottoms of drained lakes, places resembling "hog-wallows" are found, which Polyodon is thought to have dug while feeding. Such statements are difficult to substantiate and yet there is probability that they are true, for there are immense numbers of Polyodon herded in one of these almost land-locked lakes, and they feed over the muddy bottoms.

Observations on the general behavior of this fish lead me to a rather skeptical position regarding the foraging value of the rostrum. I am inclined to regard it more as a tactile organ since the sense of sight is of so little use to the fish while swimming forward. Again its use for digging seems to be restricted as indicated by the actions of this fish when its rostrum strikes against any foreign object. When, for example, Polyodon is surrounded by a seine and happens to swim against the net at any place, it very often stops when its rostrum strikes the net; sometimes it continues to push forward by one or two indifferent efforts, and then gives up entirely, turning over on its back and floating along the cork-line of the seine. In a large haul fifteen or twenty fishes may be counted floating along the cork-line with their white ventral surfaces turned upward. Sometimes they may float thus on the outside of the seine and stupidly allow themselves to be picked up by the fisherman who guards the line in a row-boat, in order to catch the fish that float over while the seine is being hauled in. The larger and more active fishes often strike the seine several times before surrendering, but even they show but little ability

to back-off when their snouts strike against the net. From such actions one is led to think that if these fish should swim with much force into mud of a very viscid consistency, they would oftentimes be trapped, for from the above observations they appear too stupid to pull back and loose themselves. Since the fish lacks the power to turn its head from side to side, it cannot stir the mud with its spatulate snout, as Jordan and Evermann claim, but must agitate the silt by a general movement of its entire body. In this process the spatula no doubt plays an important rôle since it is a considerable portion of the anterior end of the body.

The food of Polyodon is extremely abundant in the lakes, and they grow to be very large and heavily proportioned in such places. One may distinguish almost at a glance between a fish that has lived in the lakes and one from the river; the latter is poor and slender as compared with the former. The lake-fish contains a much heavier roe, averaging ten or twelve pounds, whereas river-fish often have only three or four pounds.

The stomach of Polyodon, in addition to its crustacean diet, contains great numbers of a cestode parasite, *Dibothrium hastatum* (Linton). Hundreds of these little yellow-headed tape-worms measuring three or four inches in length are often present in a single stomach.

Polyodon like Lepidosteus is frequently seen to leap from the water during the spring; the leaping at this season is not so common, however, as it is later in the year. During the summer months one may often see several of these large fishes in the air at the same time. They make a vigorous jump, usually clearing the water entirely, and at times turning over backwards in the air so as to enter the water either head foremost or by striking on their backs. Apparently one fish may sometimes be seen to jump repeatedly at short intervals near the same spot. The object of such leaping is difficult to detect unless it be on account of the stagnant and poorly aerated condition of the water during the dry summer, when it becomes unusually low in these lakes.

Polyodon shows a considerable migratory tendency. During the spring, when the water of the Mississippi River rises for several feet and backs into the bayous, thus establishing connections with the large lakes, Polyodon begins immediately to come into the

lakes from the river and continues to come in large numbers so long as a sufficient connection is maintained. To do this it must often make long journeys through rather shallow water in which many obstructions, such as bushes and trees, are frequently met. Thus it finally reaches the lakes in a rather emaciated condition and with its body scarred and scratched. By referring again to Fig. 1 the river-fish in the middle will be seen to show such marks even in the photograph. It is equally true that the fish in the river-lakes (those lakes more directly connected with the river) migrate out into the river when the water begins to back in during the spring, so that fishermen often abandon their fishing in these places at such a season, since most of the desirable Polyodon have made their escape.

SPAWNING HABITS

I was unable, on either of my trips, to find fishes in a "running" condition or to locate a party in the act of spawning. By constantly watching the fish and taking numbers in the seine each day I concluded that the breeding season in this region occurs about the middle and latter half of April. The fish seem to breed only in running water, most probably in the bayous and small wooded lakes connected with the Mississippi River. My reasons for such conclusions may be gathered from the following observations.

During the first half of the month of April five females were taken which had their ovaries well filled with almost mature eggs. On April 4, 1905, three females of not unusually large size were examined and contained respectively sixteen, thirteen, and twelve pounds of roe. Such fish were taken in the lakes until shortly after the first of May when the following condition was observed. On May 5th a female five feet and nine inches in length, which weighed eighty pounds, was found to contain only eight pounds of eggs. Many of these eggs had taken on a whitish appearance and were very soft, so that on attempting to strip them from the ovarian membranes they broke and formed a milky pulp. After this time, fish from five different lakes were examined and all were found to be in a similar condition. Not one male Polyodon in any of the

lakes was found to be "running" although I examined from ten to twenty on almost every day from April 1st until May 13th, 1905.

A number of males and females were from time to time placed in a large wire-netting pen, with the object of keeping them until they reached the spawning condition. Some of these lived in the pen for four or five days but rarely longer, although the pen was twenty feet square and rested on the bottom of the lake. The larger ones are especially difficult to keep in confinement. The eggs of the confined females soon began to degenerate and soften, like those of the lake-females mentioned above.

After April 10th, 1905, the Mississippi River began to rise and river-fish were taken in Lake Washington after April 14th; several of these females on dissection were found to have spawned. The ovaries contained only a few defective eggs still attached to the membranes of their ventral border. The anal region was inflamed and other external appearances, such as their lighter pinkish color, made it practically certain that these fishes had deposited their eggs in a normal manner. I then concluded that the large fat lake-fish was unable to spawn in the still waters, and that its eggs were absorbed within its body after they began to degenerate. The males also seem to fail to arrive at the "running" stage, as none were observed in such a condition during either season.

An attempt was made to locate a spawning party in the running bayous leading into the river. On May 16th, 1905, great numbers of Polyodon were seen swimming and darting in all directions near the surface of the water in a small bayou in Washington County, Mississippi. This was the first time these fish had been observed swimming near the surface, and their spirited actions made one think them a spawning party. A zig-zag gill net one mile in length was dropped in the midst of these fish and within less than one hour one hundred and thirty-three large Polyodon had been lifted into the flat boat. On examination they proved to be river fish that were migrating up the bayou into the lake. All of the mature ones had apparently spawned some time before. They doubtless spawned near the mouth of this bayou which was about sixty miles distant, and with the rising water they began to swim up toward the lake. The fact that the lakes are so readily depleted of their stock of Polyodon by seining and are not again

able to repopulate themselves also indicates that the fish are non-productive in such places. Lakes that have been exhausted of Polyodon will remain so for years, unless the river rises sufficiently to permit the immigration of more fish to restock them.

Only one man was found who had probably observed Polyodon in the act of spawning. He related the way in which he had rowed a boat into a party of "Spoon-bills" during April several years before, and had succeeded in killing nine of them with an oar without being able to frighten them from the place. He said that this occurred in the edge of a wooded overflow border of a bayou, several miles from where it ran into the river.

It is curious that Polyodon does not spawn in the large clear-water lakes since the related *Lepidosteus osseus* and *L. tristoechus*, both being ganoids abundant in this region, spawn in great numbers in these lakes. A spawning place of Lepidosteus was visited on April 1st, 1905, though at this time only a few unhatched eggs remained and all of the larvae had swam away. The fisherman informed me that this party had spawned about March 15th. "Runners" of both species of Lepidosteus were taken in the seine until April 20th, so that their spawning season seems to continue here for several weeks.

METHODS OF CATCHING POLYODON

The commercial value of Polyodon is scarcely indicated in Jordan and Evermann's statement,— "the flesh [is] coarse, resembling that of the larger cat-fishes, but inferior in quality." For the past ten or twelve years the roe of Polyodon has been used as a commercial substitute for sturgeon caviar. Generally the Polyodon eggs are mixed with those of the sturgeon, so that the less attractive flavor of the former is not so evident. The flesh of Polyodon is shipped to the northern cities where it is dried or smoked and sold in the markets as dried sturgeon. The rapid decrease in the supply of sturgeon for the last ten or fifteen years has caused a strong demand on the part of the dealers for a substitute, and until now Polyodon is the only one successfully tried. The demand for Polyodon has caused an extensive fishing industry

to spring up in the lower Mississippi River region, until it has become the most valuable fish of these waters. This fishing industry is conducted in various degrees of perfection, and some of the more intelligent fishermen have very extensive apparatus for procuring Polyodon. On Lake Washington, Mr. McGehee, through whose kindness I was enabled to make most of the obser-

FIG. 3. — The upper photograph shows a crew of Polyodon fishermen putting out a seine almost two miles in length; in the lower photograph they are winding it in on the reel.

vations above recorded, directs a most efficient fishery. He runs two seines, one nearly two miles long and thirty feet deep, the other about one mile long and fifteen feet deep, for use in shallower water. These huge seines are wound upon a large reel which is constructed on a heavy barge. In laying out the seine for the catch, the barge is towed by a gas launch around a circular area

more than a mile in circumference. The barge is then securely anchored and a crew of about a dozen men proceed to wind in the seine by means of the reel, as shown in the photograph, Fig. 3. It requires usually about four hours to haul the seine. Great numbers of Polyodon are caught in such a manner, more than one hundred and fifty barrels bring the record for a single haul in Lake Washington.

The roe or caviar is much more valuable than the flesh of the fish, and during my stay on these lakes there was an average of one caviar fish to every twenty-four other individuals. The roe is taken from the fish enclosed in the ovarian membranes and then strained through a screen which serves to separate the eggs. A liberal amount of a calcium-free sodium-chlorid salt is then added, and the eggs are packed in kegs for shipment to the markets. One fisherman may ship as many as seventy-five of these hundred and fifty pound kegs in a single season, from November to April. At such a rate one is not surprised to learn that Polyodon has decreased greatly in numbers since the beginning of this new industry. At present many lakes that were formerly crowded with these fish are completely depopulated. The methods of seining are very exhaustive and as above mentioned the lakes are only restocked when the river rises sufficiently, which may not occur for a period of several years. River seining is almost impossible owing to the strong currents. This industry though in its infancy is decidedly on the wane; many of the most prosperous fishermen have now abandoned it entirely on account of the great decrease in the number of fish. Such an extensive apparatus is essential for taking the large Polyodon that the fishing is unprofitable unless they are caught in great numbers.

As I have stated, my attempt to secure material for a study of the embryonic history of Polyodon was unsuccessful. The observations presented in this paper, however, indicate when and how such material may be obtained. I expect to visit these regions again and to arrange with some well equipped fisherman to seine one of the running water lakes so that fish may easily be taken during the entire season. Thus it is hoped that the desired material may be procured.

ZOOLOGICAL LABORATORY, COLUMBIA UNIVERSITY
New York

FOWLER'S "HETEROGNATHOUS FISHES" WITH A NOTE ON THE STETHAPRIONINAE[1]

C. H. EIGENMANN

At divers times and places I have pointed out that the South American heterognaths, or characins, offer us an unparalleled opportunity for a study of divergent evolution. They probably entered South America in the early Tertiary, when the continent was small and its river systems comparatively insignificant. They have literally grown up with the country, keeping pace with the development of its unrivaled freshwater system. To-day there are over one hundred genera and more then five hundred species known, and only a few spots have been examined. For the most part the genera represent steps along different directions of adaptation.

Every one identifying miscellaneous collections of fishes or other animals, without critical revision of the respective groups, will make numerous mistakes in identification; he will emphasize in his descriptions characters of no importance, and will omit or slur others that are significant. The percentage of mistakes made in identification and the number of unsatisfactory descriptions vary with different men. A large percent is found in the ichthyological writings of the late Professor Cope. His South American freshwater fishes have especially been a source of tribulation for recent writers. It is a thankless task for any naturalist to go over such work and yet this is what Dr. Henry W. Fowler has recently done for the characins.[2] Dr. Fowler has redescribed many of Cope's species and has supplied illustrations of those not figured or only unsatisfactorily figured before.

It is inevitable that new questions concerning the specimens should arise as the result of Dr. Fowler's work, and that he should

[1] Contribution from the Zoological Laboratory of Indiana University No. 90.

[2] Further Knowledge of some Heterognathous Fishes. *Proc. Acad. Nat. Sci. Phila.*, 1906, pp. 273–351 and 431–483, 60 figures.

make new mistakes. With the limited material at his command it is to be regretted that Dr. Fowler has not confined himself largely to figuring and describing, instead of bestowing new generic and subgeneric names with princely liberality and abandon. While he has helped by his figures and descriptions, he has in large measure increased, rather than lightened, the burdens of his successors.

The new genera and subgenera proposed by Dr. Fowler (24 in number) are consecutively numbered in the following notes:

1. — Ophiocephalops. This is an exact synonym of Hoplerythrinus of Gill.

2. — Copeina, a new name for the genus Holotaxis of Eigenmann, not Cope. This is probably a valid name.

3, 4, 5. — Curimata is used for Curimatus, although the latter is the earlier form. The genus is divided into the subgenera, (3) Cyphocharax, (4) Steindachnerina, (5) Peltapleura, and Curimata. The known species of the genus are not distributed to their respective subgenera and there is no evidence produced in this paper demonstrating that these subgenera are valid or that Dr. Fowler is able to delegate the species to their proper subgenera. Cyphocharax and Curimatus are probably valid. It is to be hoped that Dr. Fowler will distribute the species for us.

6. — Eigenmannina, a new generic name for *Anodus melanopogon* is apparently valid.

7. — Chilomyzon is a new subgenus of Prochilodus, distinguished by having 33–38 scales in the lateral line, whereas Prochilodus is said to have 40–60. This division is unfortunate since *P. humeralis* has 33 scales, *vimboides* 35–37, *oligolepis* 36–38; *longirostris* 38–39, *magdalenae* 40–41, *cephalotes* 41, *asper* and *hartii* 41–42, *brevis* 41–43, *rubrotaeniatus* 44, etc., to the end of the series. The new species, *Prochilodus theraponura* and *amazonensis* are very probably two stages ($2\frac{1}{4}$ and $4\frac{3}{8}$ inches long) of the common *P. insignis*.

8. — Hemiodopsis, a subgenus of Hemiodus, distinguished by having 100 scales. Since the other species of Hemiodus have 58–85 scales this division may be convenient.

9. — Pithecocharax is substituted for Anostomus because he thinks the latter is preoccupied by Anastomus *Bonnaterre* 1790.

But Anostomus was proposed by Gronovius and accepted by Scopoli in his *Introductio ad Historiam Naturalem*, 1777, p. 451. There is no reason for doing away with the name Anostomus even if it were identical with Anastomus, which it is not.

10. — Poecilosomatops is proposed for the species of Characidium having 4 scales between the anal and the lateral line; the rest have 2 or 3. The advisibility of this division may well be questioned, but even if valid, the older name, Nanognathus Boulenger, must be used instead of Poecilosomatops.

11. — Garmanina is a valid subgenus of Rhytiodus, there being a difference of 30 scales in the lateral line.

12. — Abramites (type *hypselonotus*), a new genus, is said to be distinguished from Leporinus by its longer anal basis, but where are we to draw the line? There are groups of species of Leporinus with 9, 10, 10 or 11, 11, 12, 12 or 13, 13 to 15 (*hypselonotus*), 14, and 15 or 16 rays! The name is not admissible.

Astyanax pectinatus (Cope) redescribed and figured, is the type of a genus distinct from Astyanax, differing from all other Tetragonopterinae in that the origin of the anal is under or in advance of that of the dorsal. It may be named Phenacogaster.[1] *Astyanax moorii* (Boulenger) is the type of a distinct genus which may be named Astyanacinus.[2] *Astyanax atahualpinus* does not seem to be distinct from *Moenkhausia agassizii*, since the differences fall within the limits of the observed variation of the latter. His *Astyanax oligolepis* is very probably *Astyanax steindachneri* Eigenmann; it certainly is not the *oligolepis* of Günther. *Tetragonopterus ovalis* is probably a Moenkhausia.

13. — Coscinoxyron is probably a valid genus, differing from Chalcinus in the increased number of gill-rakers.

[1] It is very probable that *Tetragonopterus bairdii* and *T. tabatingae* belong to this genus.

[2] The following description is based on the type in the British Museum.

Jaws equal, the lower not included; premaxillary with two series of teeth; mandible without conical teeth in front; gill rakers setiform; snout and maxillary forming more than half the length of the head; maxillary not slipping under preorbital for its entire length, the preorbital notched; maxillary with about 6 teeth; lateral line complete; maxillary-premaxillary border without a distinct angle. Differing from Hollandichthys and Pseudochalceus in its complete lateral line and incompletely toothed maxillary, from Creatochanes in its complete lateral line, notched preorbital and unangulated premaxillary-maxillary border.

14. — Thoracocharax, proposed as a subgenus of Gasteropelecus because the "Anterior profile of back [is] convex," is a distinct genus characterized by its dentition and not by the degree of the convexity of the back.

15. — Cyrtocharax is synonymous with Cynopotamus, a subgenus of Charax. The type of Cynopotamus lacks a second row of teeth in the lower jaw.

16. — Eucynopotamus may be used for the genus hitherto known by the name Cynopotamus, since the type of this genus does not possess the generic characters distinguishing the other species hitherto relegated to this genus from Charax. The division of this genus into a subgenus with less than 75 scales and another with more is not fortunate, since the scales are 76–77, 79–97, 110–120 and 115 respectively in *gulo*, *knerii*, *magdalenae* and *humeralis*.

17. — Cynocharax, a new *subgenus* of Roeboides, I am unable to pass judgment upon in the absence of material and through the neglect of Dr. Fowler to state what species it includes.

18. — The subgenus Sphyraenocharax is said to be distinguished by having the depth $3\frac{1}{2}$ to 4 in the length. It apparently consists of *brachycephalus* and *abbreviatus*, with the latter the type. The teeth are too imperfectly redescribed to place them. Cope's figure of *brachycephalus* shows it to be allied to the type of Acestrorhamphus. The character of the teeth of *abbreviatus* is still in doubt. Cope says: "There are two distinct large canines on the anterior part of the maxillary bone and four smaller ones; maxillary teeth are minute." Presumably the first "maxillary" is a misprint for *premaxillary*. Fowler says: "about 6 well developed [canines] in the upper" jaw. This species is also allied to the type of Acestrorhamphus. Now the type of Acestrorhamphus has a depth of $3\frac{1}{2}$, other species of the genus have a depth of 4 and I am unable to discover the semblance of an excuse for the name Sphyraenocharax.

19. — Belonocharax is a new genus based on specimens from the Truando, Rio Atrato basin. These same specimens were referred to by Gill (in 1861 I think), as Ctenolucius. Admitting that Gill's name, being undefined, has no standing, there is no excuse for passing over the *Luciocharax* (*insculptus*) of Stein-

dachner, defined and figured in his *Fischfauna des Magdalenen-Stromes*, p. 51, pl. XIII, figs. 2–2b, which is unquestionably the genus to which *Belonocharax beani* belongs, *beani* being probably identical with the type *insculptus*.

20, 21, 22. — I do not have the material to pass finally on the status on the subgenus (20) Waiteina and the genus (21) Reganina; both are apparently Colosoma, as (22) Starksina is probably a Mylosoma.

24. — The genus Sealeina is probably a valid subgenus of Metynnis.

The paper closes with descriptions and figures of Cope's two species of Stethaprion. The figures lack details of the predorsal spines which are essential. No attempt is made to compare critically these two species and pass judgment as to whether the one is simply a younger specimen ($2\frac{13}{16}$ in.) than the other ($3\frac{9}{16}$ in.) although no one else is in as good a position to do so.

The descriptions of Cope, pieced out with those here presented and the numerous figures, will enable us without prejudice to work out finally in most cases what species are really under consideration.

We must feel grateful to Dr. Fowler for his labor. But it is to be hoped that in the future he will be more conservative in adding names to the science of ichthyology. The valid names do not compensate for the work imposed on some one else to separate them from the synonyms.

An examination of Boulenger's types of Brachychalcinus shows them to belong to two distinct genera. Referring Boulenger's name to the species figured by him, the other species is congeneric with Günther's *Tetragonopterus compressus* and most nearly allied to Cope's Stethaprion. In recognition of Dr. Fowler's generous effort I would propose, using a form adopted by Dr. Fowler, the name Fowlerina to distinguish the genus represented by the *Tetragonopterus compressus* Günther.

The members of the Stethaprioninae mark the direct road from the genus Tetragonopterus (Tetragonopterinae) in its narrowest sense to the Myleinae and Serrasalminae. In the deep *Tetragonopterus argenteus* the post-ventral region is trenchant, the pre-ventral region flat. In Stichonodon both pre-ventral

and post-ventral regions are trenchant. In Stethaprion, Brachychalcinus and Fowlerina the post-ventral region is incipiently serrate and there is a pre-dorsal spine. In Mylesinus of the Myleinae the abdomen is serrate behind the ventrals and in the rest of the Myleinae and the Serrasalminae the ventral edge is serrate both in front and behind the ventrals. The descent is indicated as follows

Tetragonopterus
|
Stichonodon
|
Stethaprion — Fowlerina — Brachychalcinus
|
Mylesinus
| |
other Myleinae Serrasalminae.

The genera of Stethaprioninae are distinguished as follows.

a. No predorsal spine; caudal scaled; origin of anal posterior to dorsal. . . . . Stichonodon.

aa. A predorsal spine.

b. Predorsal spine long, slender, spear-shaped, fitting into a groove in the back; origin of anal under dorsal; scales rather small, over 60 in the lateral line.

Stethaprion.

bb. Predorsal spine scale-like, spoon or saddle-shaped, concave below, fitting into a notch in the back. Caudal scaled; scales less than 40. . . . . Fowlerina.

bbb. Predorsal spine trigger or hammer-shaped, its free portion forming a longer anterior and shorter posterior branch, both of which are sharply pointed; caudal scaled; scales large, about 40. . . . Brachychalcinus.

UNIVERSITY OF INDIANA,
Bloomington, Ind.

PINK INSECT MUTANTS

WILLIAM MORTON WHEELER

The present wide-spread interest in mutation lends fresh significance to the cases of dichromatism and trichromatism among insects, and suggests experiments in breeding these animals under laboratory control. The sporadic occurrence of pink individuals among our commonly leaf-green katydids (Locustidae) belonging to the sub-families Phaneropterinae and Pseudophyllinae, and especially in our two species of Amblycorypha, has been known for some years. Scudder called attention to some of these individuals in three brief papers (1878, 1897, 1901), and published a fine colored figure of a pair of them on a spray of golden rod.[1] From time to time other authors have recorded similar observations. Certain Homoptera, as I shall show presently, also exhibit color aberrations of the same kind. The following are the cases of pink Locustidae of which I find records in the literature:

Cyrtophyllus perspicillatus L.

No. 1. A single specimen taken at Point Pleasant, N. J. Sex and date of capture not mentioned (Lewis 1883).

C. roseus Stål.

No. 2. The type of the species from Chiriqui, Costa Rica, cited by Scudder (1901).

Amblycorypha rotundifolia Scudder.

No. 3. Female, taken August 29, on Sharp Mountain, Schuylkill County, Pa. Recorded by Scudder (1878) who received it from Leidy.

[1] Entomol. News, XII, 1901, Pl. VI. This plate is reproduced by Blatchley (1902).

No. 4. A single specimen from Pennsylvania. Date and sex not recorded (von Wattenwyl, 1878).

A. oblongifolia DeGeer

No. 5. Female, taken by Professor G. Thurber, presumably in New York State (Riley 1874).

No. 6. Specimen without record of date, sex or locality (Johnson 1889).

No. 7. Female, taken August 9, at Woods Hole, Mass., by Mrs. Sidney I. Smith (Scudder 1897).

Nos. 8 and 9. A male and a female specimen taken August 29, at Woods Hole, Mass., by Mr. Richard Rathbun and Professor A. E. Verrill (Scudder 1897, 1901).

Nos. 10 and 11. Two individuals belonging to a "number of pink specimens" taken near Bass Lake, Starke County, Indiana, by Mr. Frank Hay. Sex and date not recorded (Blatchley 1902).

Nos. 11 to 14. Three female specimens taken many years ago at West Farms, now a part of New York City, by Mr. J. Angus (American Museum of Natural History).

Nos. 15 to 17. Three specimens taken on Staten Island, N. Y., by Mr. William T. Davis. Two of these, both females, captured during August and September, are in Mr. Davis's collection.

No. 18. Female taken August 22, 1906, at Upper Montclair, N. J., by Mr. C. B. Wolff (American Museum of Natural History).

Nos. 19 to 23. Five females taken during August 1906, at Woods Hole, Mass., by members of the Marine Biological Laboratory (Professor T. H. Morgan *in litt.*).

No. 24. Male taken August 12, 1906, on Grosse Isle near Detroit, Mich., by Mr. A. S. Austin (Shull 1907).

No. 25. Female in the Museum of the University of Michigan. Date and locality not recorded (Shull 1907).

No. 26. Female taken August 31, 1907, at Winslow, N. J., by Mr. H. H. Halsted (American Museum of Natural History).

Conocephalus rosaceus Walker

No. 27. Female, the type of the species, from North China, in the British Museum (Walker 1869).

It will be noticed that the geographical range of the pink *Amblycorypha oblongifolia* is nearly or quite co-extensive with that of the green form, and that the great majority of pink individuals enumerated in the list are females. This may be due either to the females of the species in general being more numerous than the males, or to the males being much shorter-lived than the females. Careful comparison of the pink with the common green forms fails to reveal any differences, except those of pigmentation. The color of all the aberrant specimens of *Amblycorypha oblongifolia* which I have seen, is very constant, although some of those seen by others have been described as vermilion or crimson. The exquisite tint of the living insect changes rapidly after death and becomes a dull pinkish brown in the cabinet. In green individuals, however, the post-mortem color change is less marked, so that we are justified in saying that the pink pigment is less stable than the green.

The pink katydids which have been observed in confinement show nothing unusual in their behavior, nor anything to suggest a diseased or abnormal condition. Those observed both by Scudder (1901) and myself ate green leaves and drank water with avidity, and eventually laid eggs of the normal form and size. Nos. 17 and 25 each lived in a jar in my laboratory for nearly six weeks. I endeavored to mate No. 17 with a male of the green form, but failed, perhaps because the experiment was tried too late in the season, or because the male may have been moribund or exhausted before it was placed in the jar with the female. The eggs laid by this insect a few days before her death were not fertilized. No. 25 had laid a number of eggs before she was sent to me by Mr. Halsted. According to Scudder (1878), specimen No. 3 oviposited while she was still in Leidy's possession.

It seems not to be generally known that, in addition to the green and pink forms, both *Amblycorypha rotundifolia* and *A. oblongifolia* have also a brown phase. Mr. William T. Davis has generously loaned me two males of the latter species in this phase, one taken by him July 24, at Hewitt, N. J., and the other during September, on Staten Island. In these I can detect no peculiarities except those of color, the usual green being merely replaced by a yellowish brown or tan tint, which was probably more vivid in the living specimens. Several authors have recorded the occurrence

of both green and brown individuals in some of our species of cone-headed grasshoppers (*Conocephalus nebrascensis* Bruner, *C. robustus* Scudder), which are not known to have a pink phase, although Walker (1869) has based his *C. rosaceus* on a pink individual of this genus from Northern China. In *C. robustus* the brown and green colors are occasionally found in the same individual, a condition that, to my knowledge, has never been met with in the species of Amblycorypha.[1]

I find that certain green species of Homoptera belonging to the families Jassidae and Fulgoridae occasionally present striking color aberrations comparable to those of the Locustidae. Ball (1900) described as var. *paeta* a red individual of the green Jassid *Macropsis laeta* Uhler and noticed its resemblance to the pink phase of the katydids. Mr. William T. Davis has loaned me series of specimens of the jassid *Gypona geminata* Osborn, and of the fulgorid *Amphiscepa bivittata* Say which are of peculiar interest in this connection. The Gypona series comprises three specimens of the common green phase taken September 6, at Lakehurst, N. J., three brown individuals taken at the same time and place, and two pink specimens from Staten Island (September 11). There is also in the collection of the American Museum of Natural History a pink individual of the same species taken by Mr. J. Angus, at West Farms, N. Y. On closer examination the ventral surface and ground color of the pink specimens is seen to be greenish yellow (probably green in life), with irregular crimson markings on the head and thorax, and elytral veins of the same color. In the other specimens the brown and green colors are more diffused over the whole surface, especially on the dorsum, and there are no distinct markings on the head, thorax and elytra. The common form of the well-known *Amphiscepa bivittata* is pea-green, with the head, sides of thorax and scutellum, the posterior margins of the elytra and wings and the anterior legs, purplish brown. A single specimen in Mr. Davis's series has the green portions of the dorsal surface and elytra replaced by pink, with the veins of the latter somewhat

[1] Mr. Davis has shown me brown specimens of the following seven species which also present a green phase: *Conocephalus fuscostriatus* Redt., *ensiger* Harris, *lyristes* Rehn., *triops* L., *robustus* Scud., *candellianus* Davis, *exilis canorus* Davis.

purplish. This specimen, which is somewhat smaller than the green ones, was taken August 9 on Staten Island, by Mr. Joutel.

What is the significance of these peculiar pink and brown forms which appear so sporadically among our green Orthoptera and Homoptera? As Scudder says, everyone who sees one of these rare insects for the first time, "thinks at once of autumn leaves and their changes from green to red, and notices that these grasshopper cases all occur in the autumn, so far as known." But further reflection soon leads one to doubt a conclusion based on such a superficial analogy, for it is evident, in the first place, that the colors of these insects must differ greatly from chlorophyll or other plant pigments, and, in the second place, the occurrence of the pink individuals during late summer may have no significance, since it is only during this season that even those of the common green phase reach full maturity. In this connection, Scudder (1901) also calls attention to the occurrence of *Cyrtophyllus roseus* in tropical Costa Rica.

There is, however, another fact hitherto unrecorded, which seems to me effectually to dispel the notion that the pink phase can be the result of temperature acting on the green pigment. Some years ago, while I was sweeping the low vegetation in the prairies of Wisconsin and Illinois for small Diptera, I took in my net, on one or two occasions during July, a few pink larval and nymphal katydids. Unfortunately I did not preserve the specimens as I was at that time collecting Diptera only, but I retain in my memory a vivid picture of the specimens. They varied from one to two centimeters in length, and were either wingless or had small rudiments of wings. They were pink throughout, like the adults which I have seen since, and occurred sporadically in the same sweepings with many specimens of the common green form. These larval and nymphal individuals show that the pink katydid is pink throughout life and this is in all probability true *mutatis mutandis* of brown individuals and of the pink and brown Homoptera also. In other words, the pinkness or brownness are, like the greenness, congenital or germinal characters and not the result of environmental conditions. This being the case, we must incline to the hypothesis advocated by Scudder and Shull, that the pink, and probably the brown individuals also, represent sports, or

mutants, as we should now call them. They have, in fact, every appearance of belonging to a category of color forms similar to that of the albino mammals and birds and certain kinds of white-flowering plants. If there were need of coining new words, we might call the pink individuals cases of *rhodism* and the brown ones cases of *phaeism*.

Conclusive proof of the correctness of this view can be obtained only by experimental breeding. On the sport or mutation hypothesis we should expect pink individuals mated *inter se* to produce only pink individuals, and the same should result *mutatis mutandis* in the case of the brown forms. Pink or brown individuals crossed with the common green form may be expected to give offspring in the Mendelian proportion, with the pink and brown characters acting as recessives. Perhaps some student at the Marine Biological Laboratory at Woods Hole, where pink individuals of *Amblycorypha oblongifolia* seem to be less rare than in other localities, may find it worth while to perform these and other experiments for the purpose of determining the inheritance value of the characters above discussed.

Postscript

Since the foregoing paragraphs were sent to the "Naturalist" two additional captures of pink *Amblycorypha oblongifolia* have been recorded:

No. 28. A female taken August 15, 1907, by Dr. J. N. Rose, in the New York Botanical Garden and presented to the National Museum, is cited by Knab (1907), who also mentions two brown specimens of this same species, one from Springfield, Mass., and another from Dorsey, Md. (August 20, Miss R. Jones). Knab calls attention to the pink and green caterpillars of the same species as analogous to the pink and green katydids, and concludes that the difference in pigmentation in the latter is in all probability due to the red or green coloring matter of the leaves on which the insects feed. I am unable to accept this view for the following reasons: first, red and green caterpillars are sometimes found on the same green plant and living under precisely the same conditions; second, my pink katydids in confinement ate green leaves

for several weeks without showing the slightest change in coloration, and third, red vegetation is not abundant early in August, and katydids, unlike caterpillars, roam about, feeding on a variety of plants and even on animal food.

No. 29. A pink male *Amblycorypha oblongifolia* was captured by Grossbeck (1907) August 1, at Lahaway, Ocean County, N. J. He also mentions several pink specimens taken some years ago by Professor J. B. Smith in the pine barrens of New Jersey, and a pink *Amphiscepa bivittata* taken August 23, by himself at Lakehurst, N. J. He says that in his experience *Gypona octolineata* (perhaps identical with the species above cited as *G. geminata*) "is almost as often pink as green." The title of Grossbeck's paper shows that he regards the pink phases of these various insects as sports, or mutants, and not as the result of the environmental conditions (temperature, food, etc.).

LITERATURE

Ball, E. D.

1900. Notes on the species of Macropsis and Agallia of North America. *Psyche*, 1900, p. 130.

Blatchley, W. S.

1902. The Orthoptera of Indiana. *Twenty-seventh Rep. Dept. Geol. and Nat. Resources of Indiana*, 1902, pp. 351, 352. Pl.

Grossbeck, J. A.

1907. Color Sports Among the Insects. *Science*, N. S. XXVI, Nov. 8, 1907, pp. 639, 640.

Johnson, L. N.

1889. Color of Katydid. *Science*, XIII, 1889, p. 32.

Knab, F.

1907. Color Varieties of Locustidæ. *Science*, N. S. XXVI, Nov. 1, 1907, pp. 595–597.

Lewis.

1883. Change of Color in a Katydid. *Proc. Acad. Nat. Sci. Phila.*, 1883, p. 44.

Riley, C. V.

1874. Sixth Annual Report on the Noxious, Beneficial and other Insects of Missouri, 1874, p. 169.

Scudder, S. H.

1878. A Cardinal Grasshopper. *Psyche*, II, 1878, p. 189.

Scudder, S. H.
1897. Pink Locustarians. *Psyche*, VIII, 1897, pp. 54, 55.
Scudder, S. H.
1901. Pink Grasshoppers. *Entomol. News*, XII, 1901, pp. 129–131, Pl. VI.
Shull, A. F.
1907. A Color Sport among the Locustidae. *Science*, N. S. XXVI, 1907, pp. 218, 219.
Walker, F.
1869. Catalogue of the Specimens of Dermaptera Saltatoria in the Collection of the British Museum, London, 1869, pp. 321, 322.
von Wattenwyl, Brunner.
1878. Monographie der Phaneropteriden 1878, p. 269.

NOTES AND LITERATURE

GENERAL BIOLOGY

The Theory of Mimicry.— In an address before the British Association, Dr. F. A. Dixey has reviewed the history of the mimicry hypothesis as an explanation of the resemblances in color pattern between butterflies of diverse genera (*Nature*, 1907, vol. 76, p. 673–678). After visiting the Amazon nearly fifty years ago, Bates suggested that of two species of similar pattern, one was distasteful to birds, and the other had acquired a protective resemblance to it through natural selection. Dr. Dixey states that this was "the first really scientific explanation of the matter" and that it "was at once, and cordially, accepted by Darwin." He continues,—

"Bates himself was not thoroughly happy about all the facts recorded. He directs attention to the circumstance that not only do the mimics resemble their models but that the models themselves often show an extraordinary resemblance to each other. He speaks of 'a minute and palpably intentional likeness which is perfectly staggering.'" It was thought that some local or climatic cause, acting equally upon the forms of different groups, might bring about the strange resemblance between them, and "in this supposition Bates was for a time followed by Wallace."

"It is not to be denied that there is a certain plausibility in this view concerning the direct action of external conditions. It is, for example, a striking fact that the members of a mimetic group of very diverse affinities will, as Bates says, every few hundred miles change their hue and pattern together 'as if by the touch of an enchanter's wand.'"

According to Dr. Dixey the key to the puzzle why distasteful forms resemble each other was found by Fritz Müller in 1879. Dr. Dixey states that his suggestion rested on the assumption, since shown mainly by Lloyd Morgan to be correct, that birds have no instinctive knowledge of what forms should be avoided. Hence a certain number of distasteful forms must be sacrificed until their enemies have learned to leave them alone. Now if two distasteful species resemble each other so closely that birds or other enemies do not distinguish between them, the disagreeable experience gained by tasting an individual of

one species will be applied to the benefit of the other, and so each of the two species will need to contribute only a portion of the tax instead of the whole. The greater the number of forms that can be got to share the tax, the better for all, and hence the formation of large 'inedible associations' or Müllerian groups.

In Batesian mimicry the advantage is all on the side of the mimic. In a Müllerian association the benefit is mutual, and Dr. Dixey cites examples showing that two insects may *each* become modified to resemble the other. He concludes that "the fertile suggestion of Fritz Müller went far to supply what was still wanting in Bates's interpretation. Expanded by Meldola and by Poulton, accepted by travelled naturalists like Wallace and Trimen, the Müllerian generalization has proved a powerful means of interpreting many complicated relationships."

Thus the theory of mimicry has been extended to explain not only resemblances between an edible and an inedible form but also between two inedible species. The question arises whether the resemblances have anything to do with edibility. Werner believes that they have not (*Amer. Nat.*, 1907, vol. 41, p. 333). Weismann has found it necessary to gather evidence that any birds eat any species of butterflies to an important extent.[1] He states that in Germany Caspari "let about a hundred butterflies (*Vanessa antiopa*) fly from his window, but not ten of them reached the neighboring wood, all the rest being eaten by swallows which congregated in numbers in front of his window." "Kathariner observed in the highlands of Asia Minor, a flock of bee-eaters which caught in flight and swallowed a great many individuals of a very beautiful diurnal butterfly (*Thais cerisyi*)." Several other such reports are recorded from various parts of the world, but they do not establish the fact that birds devour butterflies to the extent and with the discrimination which the theory of mimicry demands. The writer's observations in New England lead to the conclusion reached by Judd, that here the native birds seldom molest butterflies. He says,[2]— In the eastern United States....there are not yet any records of birds habitually preying upon butterflies. In fact the same question has been agitated in the discussion following the reading of Mr. Dixey's most interesting paper at the London Entomological Society; and it was found that comparatively few

[1]Weismann, A. The Evolution Theory. Translated by J. A. and M. R. Thompson. Vol. 1. London, Edward Arnold, 1904.

[2]Judd, S. D. The efficiency of some protective adaptations in securing insects from birds. *Amer. Nat.*, 1899, vol. 33, p. 461–484.

members had ever seen birds take butterflies. In the eastern United States there have been hardly more than a dozen published records of birds seen in the act of taking butterflies. Birds, so far as I have observed, seem to make no practice of giving chase to the butterflies that float about them as they busily catch other insects. Butterflies seem to be avoided, whether they are indifferently colored, protectively colored or mimetic, or warningly colored. It is said by Wallace that our milkweed butterfly is imitated by Basilarchia which thus escapes capture; but, as none of our butterflies are persecuted, it seems strange if mimicry has actually been aimed at. Beddard has shown that there are difficulties in the theory of protective mimicry from the fact that mimicking and mimicked forms are eaten, and that, in certain cases, instances of apparently useless mimicry occur."

In place of the theory of mimicry, a chemical theory of animal coloration may be substituted. Dr. Gadow has described pigments as physiological products of the organism, liable to chemical transformations with corresponding changes in color. Autumn leaves turn from green to yellow and red through such processes, and if a crimson leaf of the red maple resembles one of the Japanese ivy, it is not due to mimicry. What has occurred in *Basilarchia archippus* is a transformation from blue and black to a red like that of *Anosia plexippus*. A comparable change is found in *Semnopsyche diana*; the female is blue and black, but the male is brown and red. It may be noted also that *Speyeria idalia* has red fore wings, and hind wings chiefly blue, but that in the related genus *Argynnis* (in which *Speyeria idalia* was formerly included) both pairs of wings are red. Indeed the resemblance between *Basilarchia archippus* and *Anosia plexippus* is striking, but there is a similar resemblance between the Carolina locust and *Euvanessa antiopa*, and between *Basilarchia astyanax* and *Papilio troilus*. These are not accounted for by mimicry.

If mimicry does not explain the difference in color between the male and female of *Semnopsyche diana*, it may be doubted that the dark female of the yellow *Papilio turnus* in the south is a mimic of *Laertias philenor*. The latter, according to Weismann, is protected by its unpleasant taste and odor, but the odor as described by Comstock, is undoubtedly a perfume to attract and delight its mate. A. H. Pritchett (*Biol. Bull.*, 1903, vol. 5, p. 271–287) found that *Laertias philenor* was eaten by the lizard *Sceloporus floridanus* "with evident relish" in spite of its odor and the fact that its larva fed on the ill-tasting and poisonous Aristolochia. The lizard devoured the presumably immune *Anosia plexippus* also.

Piepers [1] describes the theory of mimicry as superstition and romance which "we still hesitate to abandon, particularly in England,— in *Nature* and the *Trans. of the Entom. Soc. of London* it abounds." From the English journal *Field*, he cites the account of an Egyptian butterfly, in which the hind end so resembles the head end that a bird will be unable to know which way the insect will attempt to escape! Similarly Bashford Dean, at the recent meeting of the American Society of Zoologists in New Haven, ridiculed rather than discussed the theory. He referred to the popularity of the Indian butterfly Kallima mounted as mimic of European beech leaves.

The resemblances between butterflies of diverse genera, many of which were known to the older naturalists, remain the interesting feature. Many American books, however, instead of describing them, present the theory of mimicry with the Anosia-Basilarchia illustration, and thus "touch only the fringe of a great subject."

F. T. LEWIS.

The Inheritance of Disease.— Professor Bateson, in his last lecture before returning to England, presented a considerable list of human abnormalities which are transmissible, perhaps in Mendelian proportions. Several of these pertain to the eye. Displacement of the lens due to an asymmetrical development of its ligament, is dominant; and also *praesenile cataract*, which occurs at birth or soon after. The largest tabulation of the transmission of abnormality through the descendants of one individual, was a case of inability to see normally except in bright illumination (*hemeralopia*). Color blindness and eye color,— pure blue being recessive — were also discussed. Diagrams were shown illustrating the transmission of hypertrophied skin of palms and soles; of the tendency to blister, known as *epidermolysis bullosa*; of *diabetes insipidus*; and of *haemophilia*, in which there is extensive bleeding from slight wounds. In the last condition males are much more often affected than females, although the apparently unaffected females belonging to the families involved may transmit the disease. This was compared with the inheritance of the horned condition in sheep. A hornless breed crossed with a horned form yields horned males and hornless females, these females transmitting the horns to the males; by further crossing with the horned stock, horned females occur also. Professor Bateson believes that

[1] Piepers, M. C. Noch einmal: Mimicry, Selektion, Darwinismus. Leiden, E J. Brill, 1907. 481 pp.

the results of experimental breeding will show how various human afflictions may be eliminated.

Dr. E. E. Tyzzer (*Journ. of Med. Res.*, 1907, vol. 17, p. 199–211) discusses the inheritance of tumors in mice. Although "the analysis of data derived from a large number of human cases has failed to furnish evidence that a predisposition to cancer is inherited," it is known that some races of mice are susceptible to transplanted tumors and that other races are not. In one of the susceptible races spontaneous tumors were found in four individuals in a family of twenty-six, there being one case in each of four generations. The data obtained are insufficient "to prove or disprove that the development of a tumor is dependent upon the presence of an inherited character, although they may appear to favor this view." Further experiments upon this vital subject are in progress.

Malaria in Ancient Greece and Rome.[1] – "Modern Greece is intensely malarious.... It has been estimated that in the unhealthy year 1905, out of a total population of only about two and a half millions nearly a million people were attacked with malaria and nearly six thousand died." The three authors of the little book under consideration believe that malaria was introduced into Greece in the fifth century B. C. by "soldiers, merchants or slaves coming from Africa or Asia, the ancient homes of malaria." In the fourth century B. C., it became prevalent, and it is considered to be an important cause for the sentimentalism in art, pessimism in philosophy, and decay in morality characteristic of that century. "By 300 B. C., the Greeks had lost much of their manly vigor and intellectual strength.... Malaria made the Greek weak and inefficient; it turned the sterner Roman into a bloodthirsty brute." It was endemic in Rome probably from the second century B. C. It is implied that the modern atrocities of white men in tropical regions may be due in part to malaria; and attention is called to the immunity of Japan in contrast with the prevalence of malaria in China as an influence in modern history. The evidence for these propositions, as found in this book, will interest students of medicine, history, and the classics.

The Distribution of European Animals. — Dr. Scharff's well known *History of the European Fauna*, published in 1899 and critically dis-

[1] Malaria. A neglected factor in the history of Greece and Rome. By W. H. S. Jones. With an introduction by Major R. Ross and a concluding chapter by G. G. Ellett. London, Macmillan & Co., 1907. 108 pp.

cussed by Dr. Stejneger in the *American Naturalist* (1901, vol. 25, p. 87–116) has been followed by another book upon the same subject.[1] The problem of animal distribution is simply and clearly presented by means of outline maps on which the occurrence of a single species is plotted in black; in an unoccupied corner of each chart a picture of the animal is inserted. In a few cases the former land areas have also been indicated. Thus Fig. 6 shows a fresh water lake in place of the Irish Sea, from which the fresh water herrings (Coregonus) travelled up the streams to lakes in northern Ireland and western England and Scotland, where they are now isolated. Some of the charts deal with the distribution of plants, which are "subject to the same laws of dispersal as animals." Although "the occasional transport of species by wind or by marine currents has probably taken place sometimes," Dr. Scharff believes that it does not effect the constitution of an island fauna very materially. Twice he cites evidence that birds during migration do not have seeds in their crops or adhering to their bodies. Distribution is to be explained chiefly by geógraphical changes, and leads to such conclusions as that the Azores were not connected by land with America but only with Europe. The Canary Islands, however, "must have formed part of the land which connected Africa with America, in early Tertiary times."

Dr. Scharff believes that there was no "exceptional destruction" of the British fauna and flora during the glacial period. He is of the opinion that "the whole of the existing Irish fauna is of pre-glacial age" and that "a more uniformly humid climate of Europe may have favored the production of glaciers without decreasing the temperature." The criticisms of this hypothesis by Dr. Stejneger and others are noted by Dr. Scharff. The book is an admirable presentation of the purpose and importance of studies in animal and plant distribution.

The Dancing Mouse.[2]— Current publications have been so occupied with presenting and discussing faulty accounts of animal behavior that the public is scarcely aware of a science dealing with this subject. In a well written book entitled *The Dancing Mouse* Dr. Yerkes presents the methods and some of the results of this study. The dancing mouse, as described in the first chapters, is a domesticated animal of

[1] Scharff, R. F. European animals: their geological history and geographical distribution. New York, E. P. Dutton & Co., 1907. xiv+258 pp., 70 figs. $2.50.

[2] Yerkes, R. M. The dancing mouse. A study in animal behavior. New York. The Macmillan Company, 1907. xxi+290 pp., 33 figs. $1.25.

unknown origin, characterized by its inability to move far in a straight line without whirling or circling about with extreme rapidity. Its action may be compared with that of a cat in chasing its tail and regarded as an aimless, useless habit increased by the breeder's selection; or it may be considered an abnormal condition. Since this mouse cannot be made dizzy by any contrivance, it has been described as anatomically defective, but according to Dr. Yerkes the anatomical defects are not established and he "can see no satisfactory grounds for considering the dancer either abnormal or pathological."

The larger part of the book describes experiments with ingenious apparatus devised by the author for testing hearing, vision, educability, habit formation, efficiency of training methods, duration of habits, individual differences in behavior, and the inheritance of behavior. It is found that the dancing mouse, although able to squeak and capable of ear movements as if listening, is totally deaf except, in some instances, during the third week of life. The experiments indicate "that brightness vision is fairly acute, that color vision is poor, that although form is not clearly perceived, movement is readily perceived." The dancing mice learn some things of their own initiative, as how to use a swinging door which must be pushed on one side and pulled on the other; they are not helped by seeing other mice perform an act, but are aided by being put through it themselves. Certain acquired habits were remembered after from two to eight weeks of disuse; if forgotten, re-learning was easier. Initiative did not decrease with age up to eighteen months, the oldest studied. "Frequently my oldest mice have shown themselves preeminent in their ability to adjust their behavior to new conditions." Absolutely no evidence was found of the inheritance of an acquired habit, which in the case studied was beneficial to the animal.

These valuable studies in the mental life of the dancing mouse were accomplished without resort to vivisection. In place of depriving the mouse of its various senses, the apparatus was arranged so that they became inoperative. In methods as in results the work is highly commendable, and it has been awarded the Cartwright Prize of the Alumni Association of the College of Physicians and Surgeons, New York.

F. T. Lewis.

ZOOLOGY

Ichthyological Notes.[1] — *Fishes of Central America*: Mr. C. Tate Regan (in the Fauna Centrali- Americana, 1907) continues his account of the fishes of Central America, with good descriptions and a series of excellent figures.

He describes as new *Gerres simillimus*, the Pacific Coast representative of *Gerres* (or *Xystaema*) *cinereum*. He regards *Gerres axillaris* as distinct from *Gerres lineatus*. *Gerres embryx* and *Gerres brasilianus* are regarded as old examples of *Gerres plumieri*, a conclusion also reached by the present writer. He regards *Centropomus pedimacula* of Poey as identical with *Centropomus pectinatus*. The fish from the Pacific called *pedimacula* he identifies as *C. medius*. *C. mexicanus*, *C. gabbi*, and *C. heringi* are identified with *C. parallelus*. *C. argenteus* is the young of *C. undecimalis*. *C. viridis*, the Pacific representative of *C. undecimalis* is shown to be a distinct species. *C. affinis* and *C. scaber* are identical with *C. ensiferus* and *C. brevis* and *C. atridorsalis* with *C. armatus*. *C. altus*, a new species from Colon, is described as the Atlantic representative of *C. unionensis*. *Syngnathus spicifer*, a species from Zanzibar and the Philippines is recorded from Tehuantepec. *Doryichthys brachyurus*, a South Sea species, is recorded from Tehuantepec. *Siphostoma brevicaudum* from Vera Cruz, is regarded as identical with *Doryichthys lineatus*. *Chirostoma attenuatum* and *Ch. zirahuen* are regarded as identical with *Ch. bartoni*, and *Ch. mazquital* with *Ch. jordani*. *Chirostoma labarcae* is considered identical with *Ch. breve*, *Ch. crystallinum* with *Ch. lucius*, and *Ch. lermae* with *Ch. sphyraena*. The genus Melaniris is said to be founded on discolored specimens of Thyrina, and the species *evermanni*, *crystallina* and *balsanus* are all referred to the synonymy of *Thyrina guatemalensis*. Xenatherina, a new genus, is based on *Menidia lisa*. *Neomugil digneti* is identical with *Agonostomus nasutus*. *Joturus stipes* and *Agonostomus globiceps* are identical with *Joturus pichardi*. *Mugil gaimardianus* and *Mugil setosus* are regarded as the young of *Mugil curema*. This view may be correct, but a study of specimens in the markets of Cuba gave me a contrary impression. The well defined and thoroughly tenable genera Encinostomus and Tylosurus are not adopted by Mr. Regan, a view for which no reasons are assigned.

[1] Owing to unavoidable circumstances the proof of these notes has not been revised by President Jordan.

Fundulus guatemalensis and *F. oaxacae* are identified with *F. punctatus*. Cynodonichthys is identified with Rivulus. *Cyprinodon latifasciatus* is identified with *C. boveinus*, and *C. elegans* and *C. eximius* are placed in the same synonymy. *C. californiensis* and *C. nevadensis* are identical with *C. macularius*. *Zoogenaticus miniatus* is regarded as identical with *Z. diazi* and *Z. maculatus* with *Z. robustus*. The species *dugesi* and *quitzoensis* are referred to Zoogoneticus, while *pachycephalus* and *punctatus* are removed from their provisional station in Actinia. Limnurgus is unwarrantably used instead of the much older, but unpleasant name of Girardinichthys, and *Characodon geddesi* is placed in the synonymy of *G. innominatus*. Chapalichthys is regarded as inseparable from Characodon.

Characodon ferrugineus and *eiseni* are identical with *Ch. variatus*. *Ch. garmani* is the same as *Ch. latevalis*. Skiffia is made a synonym of Goodea. *Charaeodon duitpoldi* and *Venendum xaliscone* are referred to the synonymy of *Goodea atripinnis*. *Skiffia variegata* is the same as *Goodea lermae*. Pseudoxiphophorus is regarded as a subgenus of Gambusia. *Gambusia affinis* with its synonyms is called by the older name of *Gambusia gracilis*. *Pseudoxiphophorus pauciradiatus* is the same as *Gambusia jonesi*, and *Ps. retiaulatus* is *Gambusia bimaculata*. *Poecilia presidionis* is placed in Girardinus, which name is used instead of the prior Heteraudria which may be ineligible because no known species were assigned to it. *Heteraudria occidentalis* is placed in Poecilia. *Poecilia sphenops* is made to include *mexicana*, *thermalis*, *gillii*, *chisoyensis*, *dovii*, *vandepolli*, *arubensis*, *boucardi*, *butleri*, *limantoun*, *nelsoni* and *latipunctata*. *Platypoecilus variegatus* is referred to *Poecilia maculata*; *Mollienesia formora* is referred to *M. latipinna*; *Xiphophinus jalapae* is referred to *X. helleri*. A number of additional South American cat-fishes are recorded from Panama. *Aelunchthys nuchalis* is regarded as identical with *A. panamensis*, and *Ae.* (or *Felichthys*) *scutatus* from Panama and *Ae. isthmensis* from Colon are described as new.

Netuma vacula is referred to the synonymy of *Galeichthys planiceps*, and *Netuma clattena* to that of *G. Kessleri*; *G. azureus* to that of *G. guatemalensis*, and *G. xenauchen* to that of *G. lentiginosus*. *Galeichthys seemani* is made to include *G. jordani*, *G. gilberti* and *G. eigenmanni*; *G. guentheri* is described as new, from the Gulf of Mexico.

The name Anus is used in place of the uncertain Tachysurus, probably with justice. *Galeichthys aquaedulce* is referred to *Anus melanopus*, *Tachysurus Steindachneri* to *Anus fuerthi*, *Tachysurus emmelane* to *Anus multeradiatus* and *Cathorops gulorus* to *Anus hypophthalmus*.

The same fauna is again treated by Dr. Seth E. Meek (Publ. Field Columbian Museum) in a Synopsis of the Fishes of the Great Lakes of Nicaragua. *Rhamdia barbata* is described as new from San Francisco de Nicaragua, and *Astyanax nasutus* from Managua. *Tetragonopterus humitis* is the young of *Astyanax aeneus*. *Bramocharax elongatus* is described from Lake Managua, and *Dorosome chavesi* from several localities. *Poecilia dovii* is the same as *P. sphenops*. *Melaniris sardina* is described from Lake Managua, and *Pomadasis grandis* from Lake Nicaragua. Erythrichthus is a new sub-genus based on *Heros citrinellus*. This name should be criticised as badly formed, while the name properly spelled (Erythrichthys) is already used for a genus of fishes. Dr. Meek gives an interesting account of the phenomenon of rubrism — the prevalence of red colors in part of the individuals of these fishes. *Cichlasoma granadense* is a new species from various lakes. *Cichlasoma dorsatum* is another from Lake Managua and *C. nigritum* from Lake Nicaragua. *Heros basilaris* is the same as *C. citrinellus*, the type of Erythrichthus.

Fishes of California: In the University of California publications (Marine Laboratory of San Diego) Edwin C. Starks and Earl L. Morris of Stanford University give a list of the Marine Fishes of Southern California. In this well considered list, the range of numerous northern species is extended to the south of Point Concepcion. The single new species is a flounder, *Pleuronichthys ritteri*.

Fishes of South America: In the Proceedings of the Washington Academy of Sciences (VIII, 1907) Dr. Carl H. Eigenmann gives notes on a Collection of Fishes from Buenos Aires. The fauna is essentially that of the Amazon, although the region is not tropical. New species are *Plecostomus laplatae*, *Pomolobus melanostomus*, *Geophagus australis* and *Batrachops scotti*. The use of the family name Stolephoridae is unexplained. The type of Stolephorus is identical with that of Spratelloides and the genus belongs to the Dussumieriinae.

In the Annals and Magazine of Natural History (XIX, 1907) Mr. C. Tate Regan describes *Pimelodus boucardi* from Yucatan; *P. brachycephalus* from Guatemala; *P. rogersi* from Costa Rica; *Gambusia annectens* from Costa Rica; *G. terrabensis* from Costa Rica, and *Sicydium pittieri* from Costa Rica. *Mollienesia jonesi* (= *Pseudoxiphophorus pauciradiatus*) is identified as *Gambusia jonesi*.

In the Proc. U. S. Nat. Mus. (XXXII, 1907) Dr. Eigenmann discusses the poecilioid fishes of the La Plata Basin. New genera are

Acanthophacelus (*reticulatus*), Ilyodon (*Ilyodon paraguensis*, new species), Phalloptychus (*januarius*) and Phalloceros (*caudomaculatus*). Jenynsia is not distinct from Fitzroya.

In Archivos do Museo Nacional (Rio de Janeiro, 1907) Dr. Alipio de Miranda Ribeiro begins an elaborate account of the fishes of Brazil. The first part is devoted to morphology and physiology. The work is well done, well printed, and with good illustrative plates.

In the Ann. Mag. Nat. Hist. (XIX, 1907) Dr. G. A. Boulenger discusses the variations of *Stercolepis gigas*, "a great sea-perch from California and Japan." He maintains that the two essential points of distinction, the higher spines and the larger scales in the Japanese form, *Stereolepis ischinagi*, as compared with the Californian *S. gigas*, are both fallacious. The spines are much higher in the young fishes, and the scale count is deceptive.

I am still of the opinion that the two are distinct. The smallest specimen of Stereolepis known from Japan or California was taken by me at Santa Barbara in 1880. This has much higher spines than the adult, but the spines are still lower than in *S. ischinagi* of much larger size. In my way of counting the scales are smaller. Moreover, the young of the Japanese species have broad lengthwise stripes of black, while the American form is irregularly blotched. A study of many specimens of different ages is necessary before the question can be finally settled.

Fishes of Bermuda: In the Bulletin of the Museum of Comparative Zoology, Thomas Barbour gives notes on Bermudian Fishes, with numerous additions to the list. *Siphostoma dendriticum*, a pipe fish covered with filamentous appendages, is described from Ireland Island. *Callionymus bermudanum* is dredged off Castle and Ireland Islands. *Antennarius stellifer* is described from Castle Harbor; *Teuthis helioides*, a species of bright yellow color, is from Castle Sound, and *Holocentrus puncticulatus* from Flate's Inlet.

Fishes of the South Seas: In the Report of the Bernice Pauahi Bishop Museum of Honolulu (IV, 1906), Mr. Alvin Seele records the fishes obtained in his extensive collections in the South Seas, from the Marquesas to the Solomon Islands. The new species, 33 in number, are represented rather unsatisfactorily by photographs.

In the same report (vol. II) is a paper by William A. Bryan describing three new species of fishes from Honolulu. One of these, *Zanclus*

ruthiae is distinct from *Zanclus cornutus*. It is, however, identical with the original *Zanclus canescens* recently newly described by Mr. Regan. The other species are *Pseudoscarus heliotropinus* and *Pseudoscarus vitriolinus*. Some of the parrot-fishes previously known from Hawaii are here again described.

In Bull. Dept. Agric., Indes Neerl. (VIII, 1907) Dr. P. N. Van Kampen describes East Indian mackerels, *Scomber kanagurta*, which he identifies with *S. loo*, *S. neglectus* and *S. brachysomus*.

In the same bulletin, Dr. Van Kampen describes a new shark, *Galeocerdo fasciatus*, from the East Indies.

In the Sitzungsberichte of the Gesellschaft Naturforschender Freunde Dr. Erich Philippi notes that the cyprinodont Glaridichthys is really physoclistous, not physostomus as is supposed to be the case throughout that family. He notes also that this viviparous genus does not have a modified anal fin in the male as has been supposed, a fact already noted by Dr. Meek. The other articles are notes on the genera Glaridichthys and Cnesterodon.

In the American Journal of Anatomy, 1907, Dr. Charles R. Stockard notes the embryonic history of the crystalline lens of the California hagfish *Eptatretus stouti*, which Mr. Stockard calls by the much later name of Bdellostoma.

In the National Geographical Magazine for June, 1907, Dr. Hugh M. Smith has an article on "Our Fish Immigrants" and Dr. Gill discusses Fish that Build Nests, with a series of interesting plates.

In the Pacific Fishermen for September, 1907, Mr. Henry S. McGowan discusses the destruction of young salmon by trout. and gives photographs of stomach contents which show that in all probability the trout in the northwestern streams kill as many salmon as the fishermen, taking them when very young.

Jordan and Evermann have already shown the enormous destruction of young salmon wrought by the Dolly Varden trout (*Salvelinus malma*) in Alaska. These photographs show that the steelhead and cut throat trout are also great offenders in this regard.

Fishes of Japan: In the Proc. U. S. Nat. Mus. (XXX, 1907) Jordan gives a review of the Japanese species of Histiopteridae or boar-fish. New genera are Evistias (*acutirostris*), Zanclistius (*elevatus*), Quinquarius (*japonicus*) vice Pentaceros preoccupied, Gilchristia

(*richardsoni*) and Quadrarius (*decacanthus*). The name Velifracta is substituted for Tephritis, a genus of flounders, the latter name being preoccupied. In the same proceedings, Jordan gives a review of the Japanese Gerridae, and Jordan and Starks a list of the fishes of the Riu Kiu or Lu Chu Islands, called Okinawa in Japan. One new species, *Girella mezina*, is described. The genus Hierichthys is identical with Congrogadus.

Fishes of Siberia: In the Proc. U. S. Nat. Mus. (XXXII, 1907), Dr. Leo Berg of St. Petersburg discusses the cobitoids and the sticklebacks of the Amur region. He regards the Asiatic loach, *Misgurnus anguillicaudatus*, as a color variation of the European *Misgurnus fossilis*, the former being irregularly spotted, the latter with longitudinal stripes. He further regards all the Asiatic specimens, *Ussuria leptocephala* Nikolsky, *Misgurnus decemcirrosus* Basilewaky etc. as variants under *M. anguillicaudatus*.

Octonema (preoccupied) and Lefua (Herzenstein 1888) are older names for the genus called Elxis by Jordan and Fowler, 1903. The Japanese species is *Lefua nikkonis*. *Elxis coreanus*, *Nemacheilus dixoni* and *Octonema pleskei* are regarded as synonyms of the Mongolian species *Lefua costata*. *Orthrias oreas* from Hokkaido, Berg regards as identical with *Nemacheilus toni* from the Amur, and he thinks it is not generically and scarcely specifically different from the European *N. barbatulus*. Like Jordan and Fowler, Berg finds the common loach, *Cobitis taenia*, identical in Europe, Siberia and Japan.

The Japanese stickleback, *Pygosteus undecimalis*, is identical with *P. tymensis* (Nikolsky 1889) from Sakhalin; *Pygosteus seindachneri* and *P. bussii*, are as the present writer has already indicated, identical with *Pygosteus sinensis* from China.

Mosquito-eating fishes: In the Bulletin of the Hawaii Exp. Station, (20, 1907) Mr. D. L. Van Dine gives a valuable account of the successful introduction of Texas top-minnows, as natural enemies of mosquitoes. This was done at the instance of the present reviewer. The work was successfully accomplished by Mr. Alvin Seale under the auspices of the Honolulu Board of Health and of the Territory of Hawaii. The species secured were *Gambusia gracilis*, *Fundulus grandis* and *Mollienesia latipinna* from Galveston, Texas. 450 fishes were taken, 27 being lost on the way. All the species thrive in the new locality and all are eager in the destruction of mosquitoes, the little Gambusia perhaps most so.

Fishes of South Africa: Dr. J. D. F. Gilchrist (Marine Investigations in South Africa, 1907) describes 15 new species of fishes, some of them of special interest. Dr. Jacques Pellegrin (Assoc. Française Avanc. Sci., 1906) notes the presence of a genus of Asiatic family of Nandidae (Polycentropsis) in Africa (Rio Niger).

Fishes of New Guinea: In Resultät. Exp. Sci. Neérl. à la nouvelle Guinée (Leiden, 1907) Dr. Max Weber describes the fresh water fishes of New Guinea with many new species. This is an excellent paper, well illustrated.

Fishes of the Antarctic: In the Expedition Antarctique Française (Paris, 1907) Dr. Léon Vaillant describes the fishes, with several new species. A genus, Artedidraco, commemorates the 200th anniversary of the birthday of the "Father of Ichthyology," Petrus Artedi.

In Illustrations of the Zoology of the *Investigator* (Calcutta, 1905), Alcock and MacGilchrist figure deep sea crustaceans and fishes already described.

In the Sitzungsberichte of the Academy of Vienna (1907, XXVIII), Dr. Steindachner describes a number of fishes from Jurua, Brazil, and in two other papers, other species from streams of southern Brazil, the greatest number being from Rio Cubatao.

Dr. Louis Dollo (Proc. Royal Soc. Edinburgh, XXVII, 1907) notes the rediscovery of a singular pelagic fish, *Prymnothonus hookeri*, which he regards as an ally of Paralepis.

Mr. J. Douglas Ogilby in the Annual Report of the Amateur Fishermen's Association of Queensland (Brisbane 1907) gives a list of the species of fishes in the collection, with new generic names, undefined, but with indicated types as follows: Batrachomoeus (*coecus* DeVis) "the Greater Frog-fish," Brachaelurus (*colcloughi*, new species) the "Blue Gray Blind-shark," Coryzichthys (*diemensis* Le Sueur) the "Banded Frog-fish." These were described in a paper read March 23, 1907, but the accounts have not yet appeared. A number of new species to be described are also indicated, the types being in this collection.

In the Records of the Canterbury Museum (1907, I) Mr. Edgar R. Waite gives a list of the fishes of New Zealand, 252 species are recorded. This figure shows how far from complete is our knowledge of New Zealand fishes. It is safe to say that a thorough survey of these waters

such as Mr. Waite contemplates will yield double this number of shore-fishes, although the isolation of New Zealand is doubtless a reason why the fauna is relatively scanty as compared, for example, with that of Japan. The shore-fishes of New Zealand are for the most part distinct from those of Australia.

The writer has lately received through the courtesy of Mr. J. H. Tole of Auckland, a little known volume, Handbook of the Fishes of New Zealand, published by R. A. Sherrin, at Auckland in 1886. This book is largely a compilation, but an intelligent one.

In Zool. Anzeiger (XXVIII, 1905), Professor Robert Collett describes a number of fishes from the Azores, one of them, *Lampadena chavesi*, being new.

Dr. F. Guitel of Rennes publishes (Archiv. Zool. Exper. 1904) comparative descriptions of species of Lepadogaster the beginning of a general anatomical and systematic study of the Gobiesocidæ, in which he asks the cooperation of naturalists.

In the Smithsonian Miscellaneous Collections (1907) Dr. Theodore Gill gives an elaborate account of "Noteworthy Extra-European Cyprinids," a comparative study of dace, minnows, roach, horny-heads and shiners of America and Asia.

In another paper Dr. Gill gives an outline of the strange life-history of toad-fishes, weevers and stargazers, with plates.

Classification of Fishes: In Ann. N. Y. Acad. Science (XVII, XXIX, XXX, 1907) Dr. William K. Gregory of Columbia discusses the orders of teleostomous fishes. This is a peculiarly wise and temperate discussion of one of the most difficult of problems, the arrangement of the bony-fishes in tangible, definable and natural groups. Dr. Gregory recognizes that "degrees of blood relationship do not exactly correspond to degrees of homological structural resemblances and differences nor to the divisions of classification." He also recognizes that distinctness in groups is often dependent on the extinction of intermediate forms. He discusses in excellent fashion the strength and defects of the "English and American schemes of Classification," and shows that these are in fact nearer to each other than they appear. "The idea underlying the American method is that the best way to map out the topography of this varied morphological expanse is to assign a name to every conspicuous cluster of elevations, even if some lower elevations may connect with neighboring

systems." On the whole Gregory inclines to the American system and approves of "Gill's principle of keeping groups apart until they are shown to belong together." No linear series and no grouping of these fishes into orders and suborders can ever be satisfactory to anyone, for the forms in question exhibit a great variety of interrelations and divergences. The classification of Dr. Gregory is however about as satisfactory as any one which is current, and it represents a great amount of careful investigation and comparison.

Ecology of Fishes: In the Journal of Geology (1907) Dr. John C. Branner discusses the coastwise streams about Monterey Bay, with reference to present distribution of the fish fauna. He shows that the latter is dependent on the former courses of these streams.

In the Bull. Bureau of Fisheries (XXVI for 1906) Prof. Chauncey Juday gives an elaborate study of the Twin Lakes in Colorado, with especial reference to the food of the trout, *Salmo stomias*.

In the Rept. of the Director of the New York Aquarium, Mr. Charles H. Townsend, discusses the cultivation of fishes in ponds.

Anatomy of Fishes: In the Biological Bulletin (XII, 1907) Dr. H. D. Senior discusses the conus arteriosus of two of the most primitive of bony fishes, *Tarpon atlanticus* and *Megalops cyprinoides*, with comparison with that of other related forms. In Albula, Tarpon, and Megalops there are two rows of valves. Ordinary bony fishes have but one, while in the ganoid fishes, there are three (Amiatus) or more. In Elops, Chanos, Hiodon, Osteoglossum, Notopterus and Mormyrops, but one row of valves has been found. In Dorosoma, there is a trace of a rudimentary second row. This strengthens the suggestion that the Megalopidae, (Megalops, Tarpon) should constitute a family distinct from Elops.

In the Proc. Wash. Acad. Sciences, 1907, Mr. W. F. Allen of Stanford University discusses very fully the distribution of the sub-cutaneous vessels of the head in the gar pike and paddle fish.

In the Budgett Memorial Volume (Cambridge, England), Dr. J. Graham Kew of the University of Glasglow, discusses with great completeness the embryology of the crossopterygian fish, *Polypterus senegalus*. In this paper, Dr. Kew upholds his theory as to the origin of the vertebrate limb from modified gills rather than from a lateral fold or from a gill septum.

In the Journal of Experimental Zoology (IV, 1907), Mr. Charles R. Stockard discusses the influence of external factors, chemical and physical on the development of the egg of the killifish (Fundulus).

Fossil Fishes: In the Bull. of Geology of the University of California, Dr. D. S. Jordan describes the fossil fishes known from the rocks of California, with supplemental notes on other extinct fishes. 43 species are known from California. *Acrodus wempliae, Heptranchias andersoni, Isusus smithii, Carcharodon arnoldi, C. riversi* and *C. branneri, Xenesthes velox, Etringus scintillans, Rogenio solitudinis* and *R. bowersi*, and *Merriamella doryssa* are described as new. Xenesthes, Etringus, Rogenio and Merriamella are new genera. Rogenio, a new genus, doubtfully referred to the Cobitopsidae, shows a remarkable resemblance to the New Zealand white bait, Retropinna, and is possibly a fossil smelt. Etringus is a curious form with enamelled ganoid scales, and the body of a herring. Merriamella seems to be an athenoid with a small spinous dorsal fin.

The genus Knightia (*K. eocaena*) from the Green River Eocene is characterized, and also a new species of sucker, *Chasmistes oregonus* (Starks) from Oregon. Teeth of fossil salmon from the Quaternary of Oregon show the extreme age of the anadromous habit of the salmon of the Columbia.

In the Memoirs of the New York State Museum (X, 1907), Dr. Charles R. Eastman presents an elaborate monograph of the Devonic fishes of the New York formations, with a series of excellent plates. Interesting discussions of the relationship of Bothriolepis and other ostracophores is given, the author regarding these forms as a distinct class, but not accepting the recent bold speculations of Dr. William Patten, who compares these forms with Limulus and other spider-like crustaceans.

Mr. George P. Merrill publishes a catalogue of the fossils, minerals and ores in the United States National Museum (1907). This catalogue furnishes a useful list of the fossil fishes. All the California species above noted — even the abundant sharks' teeth — seem to be wanting in the national collection.

In the Bulletin Mus. Comp. Zool. (vol. L, 1907) Dr. Eastman discusses the dentition of the mylostomid Arthrodires, giving further reasons for regarding the Arthrodires as specialized Dipnoans. A new species is described from the Cleveland Slate, as *Mylostoma newberryi*.

In the Bulletin Amer. Mus. Nat. Hist. (XXIII, 1907), Mr. L. Hussakof describes a fossil surgeon-fish from Antigua Island, West Indies, in rocks supposed to be of Eocene Age. The species, represented by a very complete skeleton is named *Zebrasoma deani*. This species is the first of the family of Hepatidae (Teuthidae) found in America, and it is the only fossil species of the genus Zebrasoma. The pertinence of the species to the living genus Zebrasoma may be questioned. The first dorsal spine is the longest and seems semi-detached. In Zebrasoma the first is much shorter than the others. The soft fins in Zebrasoma are very high. In Z. deani, they are quite low. The caudal peduncle is slenderer in *Z. deani* and the tail much more widely forked than in any species of Zebrasoma. The number of vertebra (8 + 11 = 19) is fewer than in living Hepatidae (22). The caudal spine possibly existed, but if so, it is lost in this specimen.

If the fish is to be referred to an existing genus, Callicanthus with a slender tail and a widely forked fin, with the first of the five dorsal spines enlarged and with the vertical fins low, is nearer to the species than is Zebrasoma. The profile in Callicanthus is curved while in *Z. deani*, it is very straight.

In the Bulletin de la Societé Belge de Geologie (XXI, 1907), Dr. Louis Dollo endeavors to show that the ptyctodont fishes, supposed to be fossil chimaeroids, really belong to the order of Arthrodires. He further concludes that the chimaeras are specialized cochliodonts, changed through the necessities of deep sea life and a food of mollusks. Dr. Dollo further adds that "the idea of the Irreversibility of Evolution which has led me to the conclusions I have just justified, has once more shown its utility, else one would be led to maintain that specialized organisms might become in the process of descent again primitive, in order to become again specialized in the same or in different direction."

DAVID STARR JORDAN.

Notes on the Structure of Insects.—*A Study of the Common House-Fly.*[1] — That one need not search far for profitable objects of research is evidenced by the mass of interesting material presented by Mr. C. H. Hewitt's studies of the common house-fly, *Musca domestica*. In the first of a series of three papers dealing with the anatomy, develop-

[1] Hewitt, C. G. The structure, development, and bionomics of the house-fly, *Musca domestica*. Part 1.—The anatomy of the fly. *Quar. Journ. Micr. Sci.*, 1907, li, pp. 395–448, pls. 22–26.

ment, and bionomics of the species, is considered especially the anatomy of the adult.

Various species are popularly confused with *M. domestica* and the author therefore discusses the characters by which this — the true "house-fly" — may be distinguished. External anatomy is then considered and an attempt is made to homologize the various sclerites with those already recognized in the simpler orders of insects. Most of the terms introduced by Lowne are discarded and a number of inaccuracies in his descriptions are corrected. In the discussion of the wing veins the Comstock-Needham nomenclature is adopted since, "on account of its great morphological value it will no doubt in course of time replace the present confused system." By an oversight the free parts of M_3 and of Cu_2 are referred to as the medio-cubital and the cubito-anal cross-veins respectively.

Macroscopic features of the internal structure are described in detail, though there is little discussion of the histological features. Especially detailed are the accounts of the tracheal system, and of the musculature. The four double plates illustrating the anatomy are well executed, but the plate illustrating the imagos of *Musca domestica* and related species is too highly colored.

The Segmentation of the Insect Head.— Holmgren[1] discusses the moot question as to the number of segments in the head of the dipterous larva. In opposition to Bengtsson '97 and '05, he maintains that the suboesophageal ganglion includes but three segments. In support of his contention that the endolabium represents a separate segment, Bengtsson has cited; 1, — an independent innervation from the suboesophageal ganglia and certain suggestive structural relations of this part; 2,— the development; and 3,— comparison with other forms.

Holmgren shows that the so-called endolabial nerves of Bengtsson are muscles, as is most clearly brought out in thin sections treated with iron-haematoxylin. The slight elevation which was supposed to represent a distinct ganglion in the sub-oesophageal complex is caused by the contraction of the muscles. Postembryonic development cannot decide the question, for the presence of a fourth pair of imaginal discs with peripodal cavities does not prove that these are homodynamous with legs, and therefore with the mouth parts (cf. origin of eyes or wings).

Finally, Holmgren maintains that evidence drawn from Folsom's

[1] Holmgren, N. Zur Morphologie des Insektenkopfes. *Zool. Anz.*, 1907, Bd. xxxii, pp. 73–97.

discovery of a fourth segment in the suboesophageal ganglion of Anurida is entirely useless since the endolabium of Phalacrocera larva is not homologous with the paraglossae of the Thysanura.

The Habits and Structure of a Myriapod.— S. R. Williams[1] presents many new observations on the habits and structure of the interesting myriapod, *Scutigerella immaculata*. Its distribution, environment, light and water relations, and food habits are discussed. Experimental evidence favors the conclusion that the species is carnivorous. There is also presented considerable data regarding the eggs and the larvae. The newly-hatched larva has seven pairs of legs while the adult has twelve pairs. The author regards it as a highly specialized young, rather than a generalized ancestral form such as the hexapod larva of other diplopods is considered to be.

Musical Organs of the Cicadidae.— Among the most remarkable and effective voice-organs of the entire animal kingdom are the "drums" at the base of the abdomen of the males of the "seventeen-year locust" and their relatives in the family Cicadidae. It would seem that for these insects any other musical apparatus would be superfluous but Jacobi,[2] '07, reports finding in the cicadid genus Tettigades, from Chili, stridulating organs very similar to those already reported for certain beetles, ants, and other forms. They consist of a pair of oval, roughened file-like areas on the dorsal part of the prothorax, just within and caudad of the bases of the front wings. On the caudal angle of each front wing is a thickened flap which serves as a scraper. Unlike the abdominal musical organs these stridulating organs are equally developed in both sexes.

W. A. RILEY.

British Rhizopods:[3]— No group of organisms affords quicker or more satisfactory returns to the amateur microscopist than do the fresh water Rhizopoda, and few offer to the specialist greater opportunities for experimentation and investigation or more puzzling problems in the determination of species and the tracing of life histories.

[1] Williams, S. R. Habits and structure of *Scutigerella immaculata*. *Proc. Bost. Soc. Nat. Hist.*, 1907, xxxiii, pp. 461–485, pl. 36–38.

[2] Jacobi, A. Ein Schrillapparat bei Singcicaden. *Zool. Anz.*, 1907, xxxii, pp. 67–70.

[3] The British Freshwater Rhizopoda and Heliozoa. By James Cash and John Hopkinson. Vol. I. Rhizopoda. Part I. 150 pp. 16 Plates. London 1905.

It is therefore a matter of congratulation to all who are interested in this inviting field to learn that Messrs. Cash and Hopkinson have undertaken the preparation of a monograph of the Rhizopoda and Heliozoa of the British Isles. Penard's exhaustive treatises upon these organisms of the Swiss lakes have provided continental Europe with a very complete account of these protozoans and the present work aims at a similar analysis of the British fauna. The first volume includes the order Amoebina and a small part only of the Conchulina, proposed by the author in place of the Testacea of M. Schultze. In all, 17 genera and 46 species are described. The work is illustrated with well-executed lithographic plates and numerous text-figures, and is provided with very complete bibliographic and synonymic references, supplementing in these respects the more detailed and extensive works of Penard. The fullness of the bibliographic lists is shown by the fact that the references under *Amoeba proteus* occupy five closely set pages.

The introductory chapter discusses briefly the structure and activities of the rhizopodan cell and the structure and method of formation of the test. The discussion of the distribution and known habitats of the various genera and of the best methods of collecting rhizopods is both instructive and helpful. We note the revival of Leidy's genus Ouramoeba founded on individuals bearing a peculiar filamentous appendage. Professor W. L. Poteat has shown[1] that these supposed appendages are merely the mycelial hyphae of some parasitic fungus, a view which Penard also subsequently adopted. The authors seem not to have been aware of Poteat's work.

C. A. Kofoid.

BOTANY

Recent Studies on Gymnosperms.— Among the numerous recent contributions to our knowledge of the gymnosperms several are of more than usual importance. These deal with all the four orders and include work both on living and on fossil forms.

The discovery of spermatozoids in the cycads in 1896, and of those of Gingko at about the same time by the Japanese botanists Ikeno and Hirase, and shortly after Webber's studies on Zamia, gave a great impetus to the investigations on these very important plants, and our

[1] Poteat, W. L. Leidy's Genus Ouramoeba. *Science*, N. S. vol. 8, p. 778–782.

knowledge of these forms has been very materially increased during the past decade.

Among the most important of the more recent papers are those of Chamberlain (The Ovule and Female Gametophyte of Dioon. C. J. Chamberlain. *Bot. Gaz.*, XLII, Nov. 1906, pp. 322–358. Pls. XIII–XV. Preliminary Note on Ceratozamia. Ibid., XLIII, Feb. 1907, p. 137) and that of Caldwell on *Microcycas calocoma* (Microcycas Calocoma. O. W. Caldwell. *Bot. Gaz.*, XLIV, Aug. 1907, pp. 118–141).

The three genera treated in these papers are all peculiar to America. Dioon and Ceratozamia being Mexican, while Microcycas is confined to a limited district in the western part of Cuba.

Professor Chamberlain made careful studies in the field, where he collected a good deal of material, but his studies also included living material sent to Chicago from the region where Dioon grows. The latter is abundant in a region about twenty-five kilometers from Xalapa, the capital of the state of Santa Cruz. Apparently Dioon is confined to this very limited area. The plant much resembles Cycas, but does not attain the dimensions of *C. revoluta* or *C. circinalis* as these occur in their native habitats. The largest specimen seen had a height of only three meters; but nevertheless it was estimated that these plants were at least one thousand years old. The growth is excessively slow, and a careful study of the rate of growth of plants in cultivation has led to this extraordinary estimate of the age of the larger plants.

The plants are said to fruit freely every other year. The ovulate cones are very large, sometimes weighing six kilograms or more, and the large size of the sporophyll approximates that of Cycas, although the sporophylls are arranged in a definite cone. The lower leaves of the cone are sterile and there are intermediate forms between these sterile leaves and those that bear the ovules. Each perfect sporophyll bears two very large ovules, which may reach a length of four centimeters. The ovules do not ordinarily attain their full development unless pollination takes place.

Full details are given of the methods used in studying the development of the ovule and there is also a complete account of its morphology. The question of the possible double nature of the integument is left unsettled.

At the time of pollination there is a considerable amount of tissue at the apex of the nucellus, above the embryo sac; but later this is destroyed, partly by the growth of the pollen tubes and embryo sac,

and unquestionably the pollen tubes come into direct contact with the archegonia. A pollen chamber is present as in the other cycads, immediately after pollination. A very conspicuous jacket surrounds the endosperm, and the megaspore membrane is easily identified. The walls of these jacket cells are strongly suberized. The jacket cells seem to be concerned with the nutrition of the endosperm.

Unfortunately the younger stages of the gametophyte could not be secured. The earliest ones collected in November already had the initials of the archegonia developed. The development of the latter is probably not essentially different from that of Cycas. The prothallium is fully developed in April and at this time the archegonial chamber is complete. The megaspore membrane becomes thick and shows the clear differentiation into an endospore and exospore as in the heterosporous pteridophytes.

The archegonia are enormously large and there may be as many as ten present. As in the other cycads that have been investigated, there are two neck cells. A ventral canal cell nucleus is separated from the very large egg nucleus. The number of chromosomes was estimated to be twelve. The egg may reach a length of six millimeters, and the nucleus is correspondingly large, in some cases being as much as 600μ. in diameter. In spite of this enormous size, the nature of its minute structure was not satisfactorily made out.

The paper is accompanied by several excellent photographs and by three plates.

Chamberlain's second paper is a preliminary note on the Mexican genus Ceratozamia. This differs much in its habitat from Dioon, being a shade-loving form, while Dioon is markedly xerophytic. Fertilization was found to occur more than a year subsequent to pollination. Motile spermatozoids resembling those of Cycas and Zamia were seen. The seed has no resting period, but growth is continuous from the time of fertilization to the emergence of the young sporophyte from the seed.

Professor Caldwell's paper on *Microcycas calocoma* is a very interesting account of a little known cycad from the sierra of western Cuba.

In habit, the plant recalls *Cycas revoluta*, and like that species shows various forms of branching. The largest specimens attained a height of more than nine meters.

The ovulate cones are the largest yet known. One of these measured ninety-four centimeters in length and weighed nine and five tenths kilograms. The staminate cone is much smaller.

The most important discovery made was the remarkable character

of the male gametophyte, which is the most primitive yet discovered among the seed bearing plants. The fully developed pollen tube contains a prothallial cell, a tube nucleus, stalk nucleus and eight body cells, each of which develops two large sperm cells, thus giving rise to sixteen large spermatozoids similar to those known in several other genera of cycads. In exceptional cases as many as ten body cells were noted. Whether, as seems probable, the eight body cells are formed from the division of a primary one was not determined. The male gametophyte of Microcycas is thus seen to be less reduced than that of some heterosporous pteridophytes, *e. g.* Isoetes, Salvinia, Azolla, while no other living seed plant is known to show more than two generative cells, unless possibly Araucaria, where a large number of nuclei have been reported in the pollen tube, the exact nature of which, however, is somewhat problematical.

The development of the female gametophyte was not followed in detail, but it was found that the number of archegonia is very large, sometimes exceeding two hundred. So far as could be determined, the archegonium is of the same type as that of the other cycads.

The ripe seed contains a single large, straight embryo, with three to six cotyledons. The young plant produces a tuberous stem several centimeters in length before the first true leaf emerges. The author concludes that Microcycas is the most primitive of all the known cycads. The paper is illustrated by a number of excellent photographs and there are three plates showing the most important points in the development of the gametophyte.

The remarkable series of fossil cycads from different regions in the United States, but especially from the Black Hills of Wyoming and South Dakota has been exhaustively treated in the magnificent memoir by Wieland (American Fossil Cycads. G. R. Wieland. Carnegie Institution of Washington, No. 34, 1906). Space will not permit a complete review of this volume, which comprises nearly three hundred quarto pages, with fifty plates and many text figures. The work is mainly based upon the great collections in the museum of Yale University, the most important collection of fossil cycads in existence.

The introductory chapter deals with the discoveries and collections of fossil cycads in Europe and America. The second chapter treats of the preservation of the fossil forms and discusses at length the external characters of living cycads. A number of admirable figures are given, including some of the curious culture forms of *Cycas revoluta*, which is a favorite with Japanese gardeners. Some of these garden forms are curiously like many of the fossil cycad trunks. An interest-

ing account is given of the methods used in cutting sections of the petrified trunks. Tubular drills were employed to cut out solid cores for studying fruits, etc. These cores were then sectioned in the desired directions. In this way the trunks could be fairly well preserved.

Chapter four is concerned with the structure of the trunk, both the external layer, which is mainly composed of large, closely packed scales, "ramentum," and the internal structure, which is often preserved in a very perfect way and makes the structure of the trunks perfectly clear. For details the reader must be referred to the memoir.

The leaves of the fossil cycads have been preserved in many instances in a remarkably perfect manner, even the young unfolded leaves being clearly evident in some specimens. This is particularly the case in one species, *Cycadeoidea ingens*. The young leaves were apparently quite similar to those of Dioon or Macrozamia. As is the case with the stem, the internal structure of the leaves is also perfectly preserved.

It is the reproductive parts of these fossil cycads, however, that are of the greatest interest. While some of these are of the same type as those of the living cycads, one group, sometimes separated from the true cycads as a special order, Bennittitiales, had bisporangiate cones, which apparently were curiously like the flowers of certain angiosperms. Some of these have been preserved in a wonderfully perfect manner owing to the young cones being completely protected by the armor of scales in which they were imbedded. The "flower" consists of a central conical receptacle which bears slender sporophylls, each one terminating in a single ovule. Surrounding this ovulate receptacle was a series of pinnate microsporophylls, each one bearing a large number of "synangia," extraordinarily like those of the fern Marrattia. Surrounding the whole strobilus was a series of elongated scales or bracts very much like the floral envelopes of certain angiosperms.

The type of cone shown in these Bennettiteae is much more specialized than that of the living cycads, but it is questionable whether the resemblance to the angiospermous flower is anything more than a coincidence. Nevertheless in the search for the ancestors of the prevailing type of seed plants, one is tempted to assume an actual relationship between these and the Cycadeoideae.

The preservation of the seeds is also very perfect, and in some cases dicotyledonous embryos can be recognized within the petrified seeds. Some of the specimens of the young ovules were very perfectly preserved and these showed what seemed to be prothallial structures suggesting those of Gingko. More evidence, however, is necessary before it can be certainly decided what was the process of the development of the

prothallium and embryo. The species in which the bisporangiate cone is best shown has been named *Cycadeoidea dakotensis*.

In chapter nine there is given an excellent comparison of the existing and fossil cycads. There are but one hundred and seven described species of living cycads, included in nine genera, of which four belong to the New World and five to the Old World (including Australia). As we have seen in the consideration of Chamberlain's and Caldwell's papers, three of the four American genera are of very limited distribution, Zamia being the only American genus of fairly extended range. Three of the Old World genera, *i. e.* Cycas, Encephalartos and Macrozamia, are much more widespread. As is well known, the cycads were a predominate plant type during most of the Mesozoic, when this type reached its culmination.

The affinities of the cycads with ferns have been long recognized and Wieland's work strongly confirms the view that these have arisen from ferns of marattiaceous affinity. The extraordinarily Marattia-like microsporangial sori of Cycadeoidea are especially striking in this connection. Wieland discusses the question whether the Cycadeoideae, that is, those forms with bisporangiate cones, should be separated as a special order, Bennettitiales, as recognized, among other authorities, by Engler and Prantl. This view is not accepted by all botanists however, some of whom, like Scott, recognize three families, Cycadeae, Zamieae and Bennittiteae, all referable to a single order, Cycadales. This latter view is supported by Wieland, who believes that from the great complex of Cycadofilices or Pteridosperms (seed-bearing ferns) a group which is now known to have been highly developed during the Paleozoic, there arose the common ancestors of the true cycads and Bennittiteae, the group becoming more and more divergent as they developed through the Mesozoic. Of these two divisions, only the true cycads have survived to the present time.

The final chapter is taken up with a discussion of the relation of the cycads to the ferns and of the analogies exhibited between the flower of the Cycadeoideae and those of the angiosperms. The strong evidence that the Cycadales are descended more or less directly from marattiaceous ancestors is summarized, and after pointing out the numerous points of resemblance the author says: "Plainly the preceding résumé of the principal characters of the two great cycad groups as combined and showing their descent from marattiaceous ferns of the Paleozoic is not merely conclusive, but one of the great cornerstones upon which the plan of evolution can rest secure."

It is evident that having to deal with such an enormously compli-

cated plexus of forms as the ferns and pteridosperms of the Paleozoic, it is well nigh inpossible to come to a definite conclusion as to the question of the common origin of the cycads proper and Cycadeoideae and the question of the possible relation of these on the one hand to the other gymnosperms, and on the other to the angiosperms. "It is believed in the Cycadeoideae and especially in the persistence in such highly organized plants of the marattiaceous synangium that we get the first unmistakable hint of the nature of angiosperm evolution and the further view would seem to be justified that while the staminate disc surrounding the ovulate axis of Cycadeoidea indicates primarily an evolution terminating, so far as now possible to trace, in the gymnosperms, the juxtaposition of parts is exceedingly suggestive of the possibility, if not the manner as well, of angiosperm development directly from filicinean forms."

The discovery that many of the supposed Marattiaceae of the Paleozoic are really seed-bearing plants, Pteridosperms, emphasizes the importance of the Marattiaceae as the ancestors of the higher seed-bearing types. Whether or not we may agree with all of the author's conclusions, this magnificent memoir must remain an indispensable source of information for every student interested in the fascinating problems of the origin of the higher plants.

The development of the ovule and female gametophyte in Ginkgo are treated in a recent paper by Miss I. E. Carothers (The Development of the Ovule and Female Gametophyte in Ginkgo. *Bot. Gaz.*, 43, pp. 16–130, Feb. 1907). The most important point brought out in the course of this study is the fact that a large amount of chlorophyll is developed in the tissues of the gametophyte. This seems to be the only instance known where the endosperm develops chlorophyll, except in the case of Cycas, where it has been found that under certain conditions the prothallium may grow out of the ovule and on exposure to the light may turn green. The paper is accompanied by two plates.

Among the most important of the recent papers on the development of the Coniferae may be mentioned two by Lawson (Gametophytes, Fertilization and Embryo of Cephalotaxus Drupacea. A. A. Lawson. *Annals of Botany*, XXI, 1907. The Gametophytes and Embryo of the Cupressineæ with Special Reference to Libocedrus decurrens. Ibid., XXI, Apl. 1907).

The first of these papers deals with *Cephalotaxus drupacea*. In this species the macrospore remains undivided until a very short time before it is shed, when it divides into two cells, the tube cell and the generative cell. No vestigial prothallial cells are present. After the

separation of the stalk nucleus from the antheridial cell the latter has its nucleus divided into two equal sperm nuclei, but there is no division wall formed between them. Both sperm nuclei enter the archegonium. Probably only one megaspore develops a prothallium. The membrane is almost wanting and in this respect as well as in some others the Taxaceae are regarded as less primitive than the other conifers. The development of the prothallial tissue follows the usual course found in the Coniferae. The archegonia, which are usually four in number, offer no marked peculiarities. There are two or three neck cells, and Lawson failed to confirm the statement of Arnoldi that the nuclei of the jacket cells pass into the egg cell, and he does not think that the "proteid vacuoles" of the egg have any connection with the nuclei of the jacket cells. A ventral canal cell nucleus is always found.

Of the two sperm nuclei that enter the egg only one is functional. After fertilization the fusion nucleus divides until eight free nuclei are formed. The next divisions are accompanied by cell walls. Only one embryo is normally formed from each archegonium. The embryo shows a more or less clear division into four tiers, of which the lowermost forms a cap over the apex of the embryo proper. Very long suspensor cells develop from the tier above the embryo proper and these push the embryo into the endosperm. Secondary suspensor cells are later developed from the upper part of the embryo itself.

The author's conclusions as to the systematic position of Cephalotaxus are as follows: "From this account of the gametophytes it becomes obvious that Cephalotaxus cannot be regarded as a primitive type of the Coniferae, although this is contrary to the results obtained from certain studies on the sporophytes. . . . . Worsdell regards Cephalotaxus as the most ancient of the coniferous genera and concludes that this genus forms in a measure the connecting link between the Cycadaceae and Coniferae. . . . . By comparing the gametophytes of Cephalotaxus with the Cycadales and with the Coniferales, I cannot accept Worsdell's view. In fact I am forced to the conclusion that this genus represents a very recent type of conifer."

In the study of the Cupressineae, Dr. Lawson has taken as the principal form for study the incense cedar, *Libocedrus decurrens*, of the Pacific Coast, one of the noblest members of the family. The material was collected from the fine collection of conifers growing upon the grounds of Stanford University.

Pollination occurs in *Libocedrus decurrens* as grown at Stanford late in March or early in April. Like the other Cupressineae the pollen spores are small and each contains two cells, the smaller one

being the generative cell, which afterward divides into a stalk and body cell. The latter produces two similar male cells and this seems to be the rule in the Cupressineae. No sterile prothallial cells such as occur in the Abietineae and Cycas have been found in any Cupressineae. The other genera, in which a similar division was observed. were Cupressus, Chamaecyparis, Thuja, Cryptomeria and Taxodium. Both of the latter, according to Lawson, show close affinity with the Cupressineae, with which, however, they are not usually associated. Libocedrus, in the history of the male gametophyte, approaches most nearly to Thuja.

Two megaspore mother cells are usually present and from each of these four megaspores arise. Only one of the latter, however, develops a prothallium, the others being apparently destroyed by its further growth. The megaspore in its earlier stages of growth contains several vacuoles which ultimately fuse into a single large central one surrounded by a parietal layer of cytoplasm. In the latter are many free nuclei as in other conifers. The development of the cellular tissue from the multinucleate protoplasmic layer seems to closely resemble what has been described in various other conifers and seems to offer no marked peculiarities.

The archegonia in Libocedrus as in Thuja and Juniperus are in a compact group and number from ten to fifteen. There are five or six neck cells and as in other Cupressineae and in Cephalotaxus, the ventral canal cell is represented only by the nucleus, there being no proper ventral canal cell. The whole group of archegonia is surrounded by a layer of jacket cells, but no direct protoplasmic connection could be shown between the latter and the egg cell and it is considered probable that the transfer of food substance takes place through the cell walls.

The actual fertilization was observed in both Thuja and Chamaecyparis and in both cases it was shown that the male nucleus escapes from the cytoplasmic envelope of the male cell, and coming into contact with the egg nucleus, presses into it at one side. Finally the fusion is complete. The fusion nucleus divides until eight free nuclei result, a condition that seems to be universal in the Cupressineae. The organization of the suspensor and embryo proper agrees closely in all forms studied.

Lawson considers the Cupressineae as less primitive than the Abietineae, but more so than Cephalotaxus. Three excellent plates complete the paper.

The Araucariaceae have naturally received less attention than the

more accessible northern coniferous types and there is much need of a critical study of this important family. The important memoir of Professor Seward (The Araucarieae, Recent and Fossil. A. C. Seward, F. R. S. and Sibille O. Ford. *Phil. Trans. Royal Soc.*, series B, vol. 198, pp. 305–411, 1906) is therefore especially welcome.

The Araucariaceae are with few exceptions confined to the southern hemisphere, and although cultivated to a limited extent in the milder portions of Europe and in California they are not readily accessible to most of the students of the conifers and doubtless this largely is responsible for our imperfect knowledge of the more important points in their development.

The genus Agathis (Dammara) is confined to tropical and subtropical regions of Indo-Malaysia and Australasia. The Philippine Islands mark the northern limit of the genus. In the northern island of New Zealand, the home of the famous Kauri pine (*Agathis australis*) the latter species is said to extend to 38° S. Except for *A. robusta* of Queensland and some species from the Malay peninsula, the species of Agathis are essentially island types.

Full diagnoses are given of the species, of which eight are recognized in Agathis and eleven in Araucaria. Several doubtful species are also described. A full account is given of the anatomy of the genera and there is also included an account of the seedlings of several species of Araucaria.

Araucaria is confined entirely to the southern hemisphere, but while most of the species occur in the Australasian region, no less than five belonging to New Caledonia, there are two very distinct species in South America, *A. imbricata*, in Chile and *A. braziliensis* in Brazil. As the Araucariaceae are for the most part trees of warm, moist climates, it is not surprising that growth rings are very feebly marked or may be entirely absent. It is interesting to note, however, that Seward found in the trees of *A. imbricata* grown in England, well marked annual growth rings. The strobili, both male and female, especially in Araucaria, show very gradual transitions from the foliage leaves to the sporophylls. This seems to strengthen the view that both male and female sporophylls are directly homologous with the foliage leaves and this is the view that Seward accepts.

The male flowers of Araucaria are noticeable for their relatively large size, much exceeding that of the other conifers. The number of pollen sacs is large. These sporophylls of *A. imbricata* are 1.9 centimeters in length and may have as many as nineteen sporangia. The sporophylls of the large female cones bear a single very large seed,

which in Agathis is provided with a single wing. In Araucaria the scale develops a ligulate appendage and the ovule is imbedded in the tissue.

The ovule and embryo were only casually studied and not much is added to what we knew before in regard to these.

The fossil Araucariaceae are perhaps of even more interest than the living ones. While there is some doubt of the occurrence of true Araucariaceae in Paleozoic rocks, it is not unlikely that they already existed during the Paleozoic. In the Mesozoic they were abundant and widely distributed. Seward does not agree with those botanists who would regard the Abietineae as perhaps the oldest existing members of the Coniferae. Of Paleozoic fossils not improbably of Araucarian affinity, the genus Walchia shows the closest resemblance to the living forms. In the Jurassic there are fossils which seem to be beyond question true Araucariaceae. Such for example is *Araucarites phillipsii*, and Seward concludes that the Jurassic flora of the northern hemisphere was rich in Araucarian conifers. All of the fossil forms resemble Araucaria rather than Agathis, which is as yet unknown certainly to occur in a fossil state, although numerous fossils have been referred to the genus.

Professor Seward's conclusions as to the affinities of the Araucariaceae and by implication of the other conifers have been strongly opposed, but we believe that his conclusions will be found to be correct. He says: "We have endeavored to show that the Araucarian type is one of the oldest, if not the oldest, of the Coniferales. .... If we have evidence that the Araucariaceae are older than Abietineae, we may reasonably expect to find that the morphological characters of the older group are simpler and less specialized than those of the new group."

Seward also defends a view that we have long maintained, that there is strong reason to believe that the resemblances between the lycopods and conifers are real evidences of relationships, particularly emphasizing the resemblance between the Paleozoic Lepidocarpon and the Araucariaceae. While he recognizes the many differences in structural details between the lycopods and Araucariaceae, he does not believe that these are so great as to forbid the assumption of a lycopodineous origin for the Araucariaceae. We fully endorse his criticism of the extreme view taken by the majority of students of gymnosperms at the present time. He says, "We are disposed to think that the proof of the relationships between cycads and ferns has been allowed an undue influence in opinion regarding the ancestry of the conifers."

Of recent papers on the Gnetaceae, the present paper by Pearson on Welwitschia (Some Observations on Welwitschia mirabilis, Hooker H. H. W. Pearson, M. A., F. L. S. *Phil. Trans. Royal Soc. London*, Series B. Vol. 198, pp. 265–304. Plates 18–22. 1906.) is easily first in point of importance.

One of the most remarkable of known plants is *W. mirabilis*, which is an inhabitant of the desert strip along the coast of Portuguese and German West Africa. In January, 1904, Professor H. H. W. Pearson of the South African College in Cape Town made a visit to Walfisch Bay for the purpose of studying and collecting Welwitschia and the present memoir is a record of his observations. Owing to a native uprising his visit was cut short, and the amount of material collected was limited, but nevertheless a number of important facts were established, which add materially to our knowledge of this extraordinary plant.

The region where it grows is an almost absolutely rainless desert, and excepting at very long intervals the only source of water is the heavy sea fog, whose condensed moisture is sufficient to sustain life in a few plants. It appears, however, that in some seasons, often a good many years apart, heavy rains occur and the country may be inundated. Pearson concludes that it is only during these rare periods of heavy rain that the moisture is sufficient to germinate the seeds of Welwitschia, although these are produced freely each season. The plant does not appear to be able to exist outside the fog belt, but Pearson believes that the main source of water supply is deep seated, as is indicated by the very deep tap root of the plant.

The plants are dioecious, the flowering male plants being more conspicuous than the female. Pearson believes that Hooker's statement that pollination takes place while the ovules are still very small is incorrect and that Strasburger was right in stating that pollination does not occur until the integument of the ovule projects above the subtending bract. There is, however, strong evidence that the plant is entomophilous, as the sticky pollen is not adapted to removal by the wind and the flowers are constantly visited by insects. After pollination, fertilization and maturing of the seed seem to go on more rapidly than in any other gymnosperms. On January 13th Pearson found very few pollinated ovules, but he was informed that a month more would be sufficient for the ripening of the seeds. While this statement needs confirmation, it may very well be true, and if so, it is probably an adaptation connected with the desert habit of the plant.

The anther develops three loculi. In addition to the true tapetal

cells there is a breaking down of some of the sporogenous cells — a condition of things not at all uncommon in the sporangia of certain pteridophytes. In general there is pretty close agreement between Ephedra and Welwitschia in the structure of the stamens. The pollen spores possess three nuclei, one of which usually is completely disorganized before the spores are shed. Of these three, this disorganized nucleus presumably represents a sterile prothallial cell, while the others are respectively tube nucleus and generative nucleus. Pearson found a single archesporial cell in the megasporangium. Although some of the stages were wanting, it was concluded that the archesporial cell divides into several cells, of which one becomes the megaspore. While numbers of young embryo sacs with free nuclei were observed, no dividing nuclei were seen. No vacuole was found in the young embryo sac, a condition, by the way, which is quite similar to what obtains in Peperomia.

The upper part of the nucellus becomes more or less disorganized, and as the prothallium grows there is the usual development of cell walls between the free nuclei; but these cells later become multinucleate, presumably by the division of the original nucleus. In the lower part of the sac there may be as many as twelve nuclei, in some of these cells. The number is less in those in the upper portion of the embryo sac. The upper prothallial cells grow out into tubes penetrating the nucellar cap in much the same way that the pollen tube would do. There are several nuclei in each tube, and these are all assumed to be potentially egg cells, but this has not been definitely proven. These tubes are not to be looked upon as archegonia, but each nucleus is considered to be an egg cell as in *Gnetum gnemon* and the peculiar tube is a special adaptation which is perhaps homologous with the whole apex of the prothallium of Gnetum, with which genus Pearson seems inclined to connect Welwitschia, although of course the relationship is rather a remote one. It is understood that Professor Pearson has been engaged in further studies on this most interesting plant and the result of these studies will be looked forward to with much interest by all students of the gymnosperms.

DOUGLAS HOUGHTON CAMPBELL.

Xerophily of the Gymnosperms.— Although the foliage of the conifers apparently presents adaptations to conditions of drought, Stopes (New Phytologist, 6:46–50. 1907) finds that at the present time the conifers occupy territory in which the rainfall is, in the main, plentiful. The generally accepted explanation of the occurrence of

characters adapted to drought in environments in which they are unnecessary is that the present day plants have inherited these features from ancestral forms which grew under xerophytic conditions.[1] Miss Stopes, however, argues that in the conifers the xerophytic character is not to be regarded as an inherited adaptation but as correlated with the peculiarities of the conducting system of the stem. The gymnosperms have a much more primitive wood structure than the angiosperms and a much lower capacity for the conduction of water. It is this lower efficiency as conductors of water that necessitates the xerophytic character of the foliage,— not the environment. In other words, the author regards the xerophily of this group as phylogenetic, not adaptive.

With Miss Stope's general conclusion that the xerophily of the Coniferales is phylogenetic and not ecological, Moss agrees (New Phytologist 6 : 183–185. 1906),[2] but he feels that there is an untenable assumption running through the whole of her argument. This assumption is that the conifers in question are more pronounced xerophytes than the angiosperms with which they are ecologically associated. The xerophily of the gymnosperms is seen in the greatly reduced surface of the acicular leaf, whereas that of the angiosperms takes the form of a deciduous habit by which the transpiration is reduced to practically zero during the season of physiological dryness of the soil. He finds that in many instances deciduous angiospermous trees which are commonly regarded as mesophytes, extend into higher altitudes and latitudes than conifers which are generally classed as fine examples of xerophytes. Furthermore, he finds that among both conifers and dicotyledons, the deciduous species are the ones which extend the farthest north.

In view of these facts Moss would consider that the xerophily of the

[1] Clements (Res. Meth. Ecol. 127, 1905) has suggested that the xerophytic characters of bog plants are not due to the "physiological dryness" of their substratum as proposed by Schimper and generally accepted, but to the inheritance of characters acquired when their ancestors were growing in xerophytic environments. He would therefore suggest the origin of stable adaptive structures which persist when the forms which had acquired them are subjected to ecological conditions of the most diverse type.

[2] Moss writes: "With her general contention, that the xerophily of the Coniferales is inherited and not acquired, I do not propose to deal, as Miss Stopes amply proves her case." The sentence is somewhat confusing, but by "inherited" he evidently means phylogenetic in the sense in which Miss Stopes uses the term while "acquired" is equivalent to her "ecological" or "inherited."

conifers is in no wise out of place in the environment of our mesophytic forests, for these are ecologically xerophytic for over half the year. He also holds that in the acicular leaf and the deciduous habit of some of the northern conifers we have more recent adaptations to the demands of a xerophytic habitat, thus accounting for the present wide distribution of this primitive group and its successful competition with phylogenetically higher forms.

The arguments of both of these writers are suggestive, and much of the value of such discussions lies in the emphasis which they lay upon the necessity of approaching these problems with more precise methods than have hitherto been employed.

J. Arthur Harris

Notes on the Problem of Adaptation.— *The Stinging Property of the Giant Nettle tree.* The giant nettle tree, *Laportea gigas*, a native of Australia often attaining a height of over a hundred feet, has long been noted for the violence of its action. Its large juicy leaves are covered with numerous strong hairs or bristles which are filled with a powerful stinging fluid. If the leaves be lightly brushed these hairs penetrate and break in the skin, causing pain which gradually increases in severity and sometimes lasts for several days. A popular name for the Laportea is "mad tree." Petrie (Proc. Linn. Soc. N. S. W., 31: 530–545. 1906) presents a detailed account of the chemical composition and physiological action of the juices of this tree. He suggests five functions for the organic acids which are found in especial abundance, and states that "after considering the various functions in which organic acids take part, we cannot believe that the function of protection is the only one in this case."

Assimilatory Tissue in Mangrove Seedlings. Schimper was inclined to doubt the assimilatory function of the hypocotyl of mangrove seedlings but Goebel and Haberlandt acknowledge that they may perform this function. Carson (New. Phytologist, 6:178–183. 1907) describes the structure of the chlorophyll-containing tissue of the hypocotyl of Bruguiera and Rhizophora, and thinks it safe to assume that in the Rhizophoraceae generally the "hypocotyl is an assimilatory organ and is definitely modified for assimilatory purposes."

Benzoic Acid in Pinguilica. Insects which die in great numbers on the leaves of *Pinguilica vulgaris* emit no putrid odor. Experiments performed by Loew several years ago indicated the presence of some antiseptic substance. Loew and Asō (Bull. Coll. Agric. Imp. Univ.

Tokyo, 7: 411–412. 1907; also Bot. Mag. Tokyo, 21:107–109. 1907) conclude that benzoic acid is the substance which prevents putrefaction. Thus Pinguilica differs from Utricularia in which the captured organisms putrify.

Biologists are much less inclined than formerly to attribute adaptive significance to the characters separating closely related species. Nevertheless Focke (Abh. Naturw. Ver. Bremen, 19:82. 1907) holds that closely related forms are adapted to slightly different habitats. He gives a list of several plant species which he thinks illustrates this point.

Davidson (Agric. Journ. Cape Good Hope, 31:175–177. 1907) calls the attention of botanists to the interesting structural peculiarities of the tuberous Liliaceous genus Eriospermum.

J. A. H.

Plant Cultivation in Art and Education.[1]— During the past few years there has been unusual interest in the possibilities of artistic gardening, both in the country and the city. This is evidenced by the publication of such elegant magazines as the *Country Calender, Suburban Life, Country Life in America*, and the *Garden Magazine*, as well as by the attention which civic leagues everywhere are giving to parks and highways. Many of the publications of the park commissioners of our cities are prepared and published with the most fastidious care, and in them plant cultivation has a prominent place.

The English are still much in advance of Americans in these matters —in interest, theory, and practice. During the last few weeks we note the publication of such works as Kingsley's "Eversley Garden and Others," Thonger's "Book of Rock and Water Gardens," Davidson's "Unheated Greenhouse," and the more pretentious "Art and Craft of Garden Making" by Mawson. On this side of the water

[1] Kingsley, Rose G. Eversley Garden and Others. London. George Allen. 1907. 6 s.

Thonger, C. The Book of Rock and Water Gardens. London & New York. John Lane. 1907. $1.00.

Davidson, K. L. The Unheated Greenhouse. London. The Country Life Co. 1907. 8 s, 6 d.

Mawson, T. H. The Art and Craft of Garden Making. 3 ed. London. B. T. Botsford. 1907.

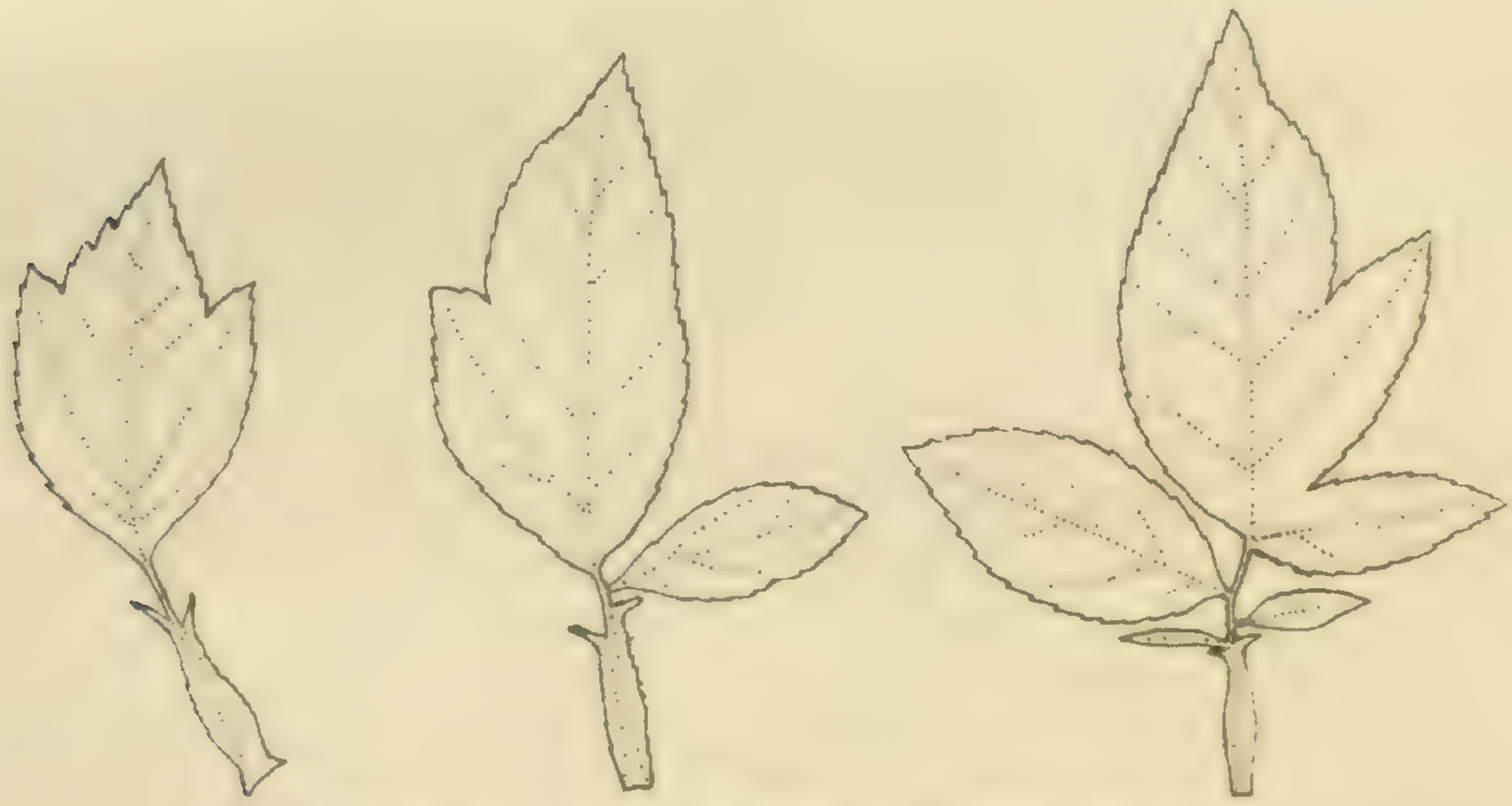
Bisset, P. The Book of Water Gardening. New York. A. T. De La Mare. 1907.

we may record Bissett's "Book of Water Gardening." This is not the place to discuss the merits of these volumes as practical guides or as teachers of art, but in all of them the skill of the photographer has been fully utilized in supplying illustrations, and these the systematic botanist may find of considerable interest. Another finely illustrated work is Perrédès's "London Botanic Gardens," recently reprinted in book form.

The interest in these matters is further evidenced by Baker's discussion of the problems of horticultural education (Journ. Roy. Hort. Soc., 22:152–162. 1907); True's consideration of the advisability of the introduction of elementary agriculture into schools (Yearb. U. S. Dep. Agric., 1906:151–154. 1907); and Cook's arguments in favor of agriculture as the basis of education (Monist, 17:347–364. 1907).

J. Arthur Harris.

Lobed Terminal Leaflets in the Rose.— In discussing the development of pinnate leaves the writer stated that lobed terminal leaflets were not found in the rose. It seemed probable that they would appear, since they occur in the related agrimony, but among twenty-seven hundred leaves of the wild *Rosa lucida* not a single example was found.



Leaves of the cultivated rose. ⅓ natural size.

The writer is indebted to Miss Margaret W. Whitney of Pasadena, California, for the lobed leaves of the cultivated rose shown in the accompanying drawing. They indicate that the basifugal tendency is present in the stipular type of basipetal leaves, and that it may predominate.

F. T. Lewis.

PUBLICATIONS RECEIVED

From October 1 to December 1, regular exchanges not included
The year of publication, when not otherwise noted, is 1907

CLEMENTS, F. E. *Plant Physiology and Ecology.* New York, Henry Holt and Company, 1907. 315 pp., 125 illus.— CURTIS, C. C. *Nature and Development of Plants.* New York, Henry Holt and Company, 1907. 471 pp., 342 figs. $2.50.— GAGE, A. P. AND GOODSPEED, A. W. *Principles of Physics.* Boston, Ginn and Company, 1907. 12mo, 547 pp., illus. $1.50.— GREEN, J. R. *An Introduction to Vegetable Physiology.* Philadelphia, P. Blakiston's Son and Co., 1907. 2nd ed., 459 pp., 182 figs., $3.00.— HUNTER, G. W. *Elements of Biology.* New York. American Book Company, 1907. 8vo, 445 pp., illus. $1.25.— JONES, W. H. S., ROSS, R., AND ELLETT, G. G. *Malaria, a neglected Factor in the History of Greece and Rome.* London, Macmillan and Bowes, 1907. 108 pp.— KELLOGG, V. L. *Darwinism Today.* New York, Henry Holt and Company, 1907. 403 pp. $2.00.— LAMARCK, J. B. *Discours D'Ouverture des Cours de Zoologie (An VIII, An X, An XI et 1806).* Paris, Bulletin Scientifique, 1907. 157 pp.— MULLENS, W. H. *Gilbert White of Selborne.* London, Witherby & Co., 1907. 32 pp., 7 pls. 2s 6d.— SCHARFF, R. F. *European Animals, their Geological History and Geographical Distribution.* New York, E. P. Dutton and Co., 1907. 258 pp., 70 figs. $2.50.— STEVENS, W. C. *Plant Anatomy.* Philadelphia, P. Blakiston's Son & Co., 1907. 349 pp., 136 illus. $2.00.— WRIGHT, M. O. *Gray Lady and the Birds.* New York, The Macmillan Company, 1907. 437 pp., illus. $1.75.

BARTSCH, P. New marine mollusks from the west coast of America. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 177–183.— BOVARD, J. F. The structure and movements of Condylostoma patens. *Univ. of Cal. Pub.*, zool., vol. 3, no. 14, pp. 343–368, pl. 34, 21 text-figs.— BUFFUM, B. C. The life and preservation of pitch pine fence posts. *Wyo. Exp. Sta.*, bull. 75, 18 pp., 7 pls.— BURCKHARDT, R. Das zentral-nervensystem der Selachier als Grundlage für eine phylogenie des vertebratenhirus. *Abh. d. kais. Leopoldinisch-Carolinischen deutsch. Akad. d. Naturf.*, vol. 73, pp. 241–450, 4 pls.— CARTER, L. E. Experiments in swine feeding. *Io. Exp. Sta.*, bull. 91, 17 pp.— CASEY, T. L. A revision of the American components of the Tenebrionid subfamily, Tentyriinae. *Proc. Wash. Acad. of Sci.*, vol. 9, pp. 275–522.— CAUDELL, A. N. On some earwigs (Forficulidae) collected in Guatemala by Messrs. Schwarz and Barber. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 169–176.— COUTIÈRE, H. Sur quelques formes larvaires énigmatiques d'Eucyphotes, provenant des collections de S. A. S. le Prince de Monaco. *Bull. Inst. Océanog.*, no. 104, 69 pp., 22 figs.— DALL, W. H. Supplementary notes on Martyn's Universal Conchologist. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 185–192.— DE LA BARREDA. L. Las plagas del algodonero. *Com. Parasitol. Agric.*, vol. 4, no. 2, pp. 107–215, 24 pls.— DUERDEN, J. E. Death-feigning instinct in the ostrich. *Rep. of So. African Assoc. for the Adv. of Sci.*, 1906, pp. 209–212.— DUERDEN, J. E.

Experiments with ostriches. *Cape of Good Hope, Agric. Jour.*, nos. 11 and 12, 16 pp., 3 pls.— DUERDEN, J. E. The morphology of the Madreporaria,— The primary septa of the Rugosa. *Ann. and Mag. of Nat. Hist.*, ser. 7, vol. 18, 1906, pp. 226–242, 21 figs.— DUERDEN, J. E. Genetics of the colour pattern in tortoises of the genus Homopus and its allies. *Rec. of the Albany Mus.*, vol. 2, no. 1, pp 65–92, pls. 6–8.— DUERDEN, J. E. Variations in the geometrica-group of South African tortoises. *Rep. of So. African Assoc. for the Adv. of Sci.*, 1906, pp. 178–208.— FIELD, I. A. Unutilized fishes and their relation to the fishing industries. *U. S. Bur. Fisheries*, doc. 622, 50 pp., 1 pl.— GARCÍA, F. Codling moth investigations during 1903 and 1904. *N. M. Exp. Sta.*, bull. 65, 29 pp.— GOLDTHWAIT, J. W. The abandoned shorelines of eastern Wisconsin. *Wis. Geol. and Nat. Hist. Sur.*, bull. 17, 134 pp., 36 pls.— GREEN, E. E. AND MANN, H. H. The Coccidae attacking the tea plant in India and Ceylon. *Mem. Dept. of Agric. in India*, ento. ser., vol. 1, no. 5, pp. 337–355, pls. 16–19.— HALL, W. L. The waning hardwood supply and the Appalachian forests. *U. S. Dept. of Agric.*, forest service, circ. 116, 16 pp.— HATTA, S. On the gastrulation in Petromyzon. *Jour. College of Sci., Imp. Univ. of Tokyo*, vol. 21, art. 2, 44 pp., 3 pls.— HERRERA, A. L. El polvo de crisantema y las plantas que lo producen. *Com. Parasitol. Agric.*, circ. 61, 24 pp., 6 figs.— HERZOG, T. Studien über den formenkreis von trichostomum mutabile. *Abh. d. kais. Leopoldinisch-Carolinischen deutsch. Akad. d. Naturf.*, vol. 73, pp. 451–498, 7 pls.— HILLMAN, F. H. Dodder in relation to farm seeds. *U. S. Dept. of Agric.*, farmers' bull. 306, 27 pp., 10 figs.— HUNTER, W. D. The most important step in the control of the boll weevil. *U. S. Dept. of Agric., Bur. of Ento.*, circ. 95, 8 pp.— HUNTER, W. D. AND HOOKER, W. A. Information concerning the North American fever tick. *U. S. Dept. of Agric., Bur. of Ento.*, bull. 72, 87 pp., 13 figs.— JAQUET, M. Note sur une forme jeune de Trigla. *Bull. Inst. Océanog.*, no. 102, 5 pp., 1 pl.— JORDAN, D. S. AND HERRE, A. C. A review of the Cirrhitoid fishes of Japan. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 157–167.— JORDAN, D. S. AND SYNDER, J. O. Notes on fishes of Hawaii, with descriptions of new species. *Bur. of Fisheries*, doc. 623, pp. 205–218, pls. 12, 13.— JOUBIN, L. Note sur les Brachiopodes recueillis au cours des dernières croisières du Prince de Monaco. *Bull. Inst. Océanog.*, no. 103, 9 pp.— KENNEDY, W. J., ROBBINS, E. T. AND BOUSKA, F. W. Tuberculosis in swine. *Io. Exp. Sta.*, bull. 92, 24 pp.— LANTZ, D. E. An economic study of field mice. *U. S. Dept. of Agric.*, biol. sur., bull. 31, 64 pp., 8 pls.— LEVINSEN, G. M. R. Sur la régénération totale des Bryozoaires. *D. K. D. Vid. Selsk. Overs.*, no. 4, pp. 151–159, 1 pl.— LINTON, E. Notes on parasites of Bermuda fishes. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 85–126, pls. 1–15.— MACBRIDE, T. H. On certain fossil plant remains in the Iowa herbarium. *Proc. Davenport Acad. of Sci.*, vol. 10, pp. 153–162, 12 pls.— MACÍAS, C. Estudio experimental de la Nitragina en la Hacienda de Zimatepec. *Com. Parasitol. Agric.*, circ. 62, 4 pp., 5 figs.— MADSEN, T. AND NYMAN, M. Contributions aux études théoriques sur la désinfection. *D. K. D. Vid. Selsk. Overs.*, no. 3, pp. 105–126.— MASON, O. T. Basketry bolo case from Basilan Island. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 193–196, 1 fig.— MORRILL, A. W. La Conchuela Mexicana en la parte occidental del estado de Texas en 1905. *Com. Parasitol. Agric.*, cir. 63, 25 pp., 4 figs.— MORTON, G. E. Ration experiments with swine. *Wyo. Exp. Sta.*,

bull. 74, 18 pp., 2 figs.— OSTERHOUT, W. J. V. On nutrient and balanced solutions. *Univ. of Cal. Pub.*, bot., vol. 2, no. 15, pp. 317–318.— RITTER, W. E. The Ascidians collected by the United States Fisheries Bureau steamer Albatross on the coast of California during the summer of 1904. *Univ. of Cal. Pub.*, zool., vol. 4, no. 1, pp. 1–52, pls. 1–3.— SEALE, A. AND BEAN, B. A. On a collection of fishes from the Philippine Islands, made by Maj. E. A. Mearns, surgeon, U. S. Army, with descriptions of seven new species. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 229–248.— SETCHELL, W. A. Some unreported Alaskan Sphagna. *Univ. of Cal. Pub.*, bot., vol. 2, no. 14, pp. 309–315.— SMITH, B. G. Preliminary report on the embryology of Cryptobranchus allegheniensis. *Biol. Bull.*, vol. 11, no. 3, 1906, pp. 146–164, pl. 3.— SMITH, B. G. The life history and habits of Cryptobranchus allegheniensis. *Biol. Bull.*, vol. 13, no. 1, pp. 5–39, 14 figs.— STEVENSON, C. H. Whalebone: its production and utilization. *Bur. of Fisheries*, doc. 626, 12 pp., 3 pls.— STOCKBERGER, W. W. Growing and curing hops. *U. S. Dept. of Agric.*, farmers' bull. 304, 39 pp., 20 figs.— STOCKBERGER, W. W. The drug known as pinkroot. *U. S. Dept. of Agric.*, bur. of plant industry, bull. 100, pt. 5, 1906, 8 pp., 4 figs.— SULLIVAN, M. X. The physiology of the digestive tract of Elasmobranchs. *Bull. Bur. of Fisheries*, vol. 28, pp. 1–27, pl. 1.— USSING, N. V. Om floddale og randmoraener i Jylland. *D. K. D. Selsk. Overs.*, no. 4, pp. 161–213.— WALSINGHAM, LORD. Descriptions of new North American Tineid moths, with a generic table of the family Blastobasidae. *Proc. U. S. Nat. Mus.*, vol. 33, pp. 197–228.— WEIDMAN, S. The geology of north central Wisconsin. *Wis. Geol. and Nat. Hist. Sur.*, bull. 16, 697 pp., 76 pls.— WESTER, P. J. Roselle: its culture and uses. *U. S. Dept. of Agric.*, farmers' bull. 307, 16 pp., 6 figs.

ANALES DEL MUSEO NACIONAL DE MONTEVIDEO, vol. 6.— ANNUAL REPORT OF THE OFFICE OF EXPERIMENT STATIONS FOR THE YEAR ENDED JUNE 30, 1906.— BULLETIN OF THE CHARLESTON MUSEUM, vol. 3, no. 6.— BUREAU OF FISHERIES DOCUMENTS nos. 620, 621.— PROCEEDINGS OF THE LINNEAN SOCIETY OF NEW SOUTH WALES, vol. 32, pt. 2.— PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM, vol. 32.— SECOND REPORT OF THE NATAL GOVERNMENT MUSEUM.— STATUTS DE LA FONDATION NOBEL.

(No. 491 was issued December 9, 1907)

THE JOURNAL OF EXPERIMENTAL ZOÖLOGY

EDITED BY

WILLIAM K. BROOKS
WILLIAM E. CASTLE
EDWIN G. CONKLIN
CHARLES B. DAVENPORT
HERBERT S. JENNINGS
FRANK R. LILLIE
JACQUES LOEB
THOMAS H. MORGAN
GEORGE H. PARKER
CHARLES O. WHITMAN
EDMUND B. WILSON

ROSS G. HARRISON, Managing Editor

CONTENTS

VOLUME V. NO. 1. NOVEMBER 1907

DAVID D. WHITNEY
Determination of Sex in Hydatina Senta.

ARTHUR B. LAMB
A New Explanation of the Mechanics of Mitosis.

HERBERT EUGENE WALTER
The Reactions of Planarians to Light.

VOLUME V. NO. 2. IN PRESS

HERBERT EUGENE WALTER
The Reactions of Planarians to Light. (Continued from No. 1.)

MARY ISABELLE STEELE
Regeneration in Compound Eyes of Crustacea.

ALEXANDER PETRUNKEVITCH
Studies in Adaptation. 1.—The Sense of Sight in Spiders.

PRICE OF SUBSCRIPTION PER VOLUME
(PAYABLE IN ADVANCE)

To Subscribers in the United States, Canada and Mexico	$5.00
To subscribers in other countries	$5.50
Price of single copies	$2.00

These prices are net and under no condition subject to discount

Remittance should be made by Postal Money Order (Mandat de Poste, Postanweisung) or by draft on New York, payable to the Journal of Experimental Zoölogy.

Address all communications to

THE JOURNAL OF EXPERIMENTAL ZOÖLOGY

2 Hillhouse Avenue, . New Haven, Conn. U. S. A.

ALONE IN ITS FIELD

THE LIVING AGE

is the only American Magazine exclusively devoted to the reprinting, without abridgment, of the most important and interesting articles from the best English periodicals.

Published weekly, it is able to present this material while the topics considered are still fresh in the public mind.

With the whole range of English periodical literature to select from, it is able to present more important articles by well-known and brilliant writers than any other single magazine. It publishes

The Best Fiction **The Best Essays**

The Best Literary Criticism

The Best Travel Articles

The Ablest Discussions of Public Affairs

The single numbers are light and easy to hold, and the reading matter is not smothered in advertising. The numbers for a year contain as much as two of the four-dollar magazines.

The LIVING AGE has been published every Saturday without missing an issue for more than 63 years, and was never more indispensable than now to intelligent readers.

New subscribers for 1908 will receive free the remaining numbers of 1907 from the date on which their subscriptions reach the publishers. Specimen copy free.

Terms: $6.00 a year

Three Months' Trial Subscription, $1.00

THE LIVING AGE COMPANY

6 Beacon Street, Boston, Mass.